CPU®

COMPUTER POWER USER

MRM™
MAD READER MOD

Rey's Speeder

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DID YOU FIND THE HIDDEN *CPU* LOGOS ON OUR COVER?

Gotcha. Here they are.

ENERMAX Debuts LIQTECH TR4 Series

ENERMAX has announced a new series of all-in-one liquid coolers designed especially for AMD's new high-end Threadripper CPUs. The LIQTECH TR4 cooler series includes two models, the LIQTECH TR4 240 and LIQTECH TR4 360. ENERMAX uses a patented design called Shunt-Channel-Technology (SCT) in the cooling blocks for the LIQTECH TR4 series that the company says improves overall heat transfer and prevents the build-up of hot spots. ENERMAX also designed a new pump for the coolers that increases liquid flow, and it made sure the base plate on the coolers covers all of Threadripper's integrated heat spreader. Altogether, the technologies and design of the LIQTECH TR4 series help the coolers provide up to 500W+ of TDP. The coolers come with custom mounting kits, and ENERMAX has videos available to walk users through the installation process. The MSRP for the LIQTECH TR4 240 is $129.99; the triple-fan LIQTECH TR4 360 goes for $149.99.

Corsair Adds VOID PRO Headsets

Corsair has added three new models to its lineup of VOID PRO gaming headsets. All three feature the same basic cast-aluminum construction, with a metal reinforced headband and memory foam over-the-ear cups. The three models differ in color options, lighting capability, and connectivity features. The base model is the VOID PRO SURROUND, which is available in red and carbon colors and offers Dolby 7.1 surround sound. The VOID PRO RGB USB adds in some lighting bling in each earcup; it comes in carbon and white. The VOID PRO RGB WIRELESS also offers RGB, but in a model that can connect wirelessly at distances up to 40 feet. Corsair says the wireless model comes in carbon, white, and yellow, and it has a battery life of 16 hours. The VOID PRO SURROUND and VOID PRO RGB USB models carry an MSRP of $79.99. The VOID PRO RGB WIRELESS carbon and white models run $99.99, while the striking yellow SE (Special Edition) model includes a base station for your wireless USB adapter and will cost you $129.99.

WATCHING THE CHIPS FALL

Here is the pricing information for various AMD and Intel CPUs.

CPU	Released	Original Price	Last Month's Price	Online Retail Price*
AMD Ryzen Threadripper 1950X (Zen)	8/10/2017	$999.99	n/a	$1,019.99
AMD Ryzen Threadripper 1920X (Zen)	8/10/2017	$799.99	n/a	$799.99
AMD Ryzen 7 1800X (Zen)	3/2/2017	$499	$449.99	$459.99
AMD Ryzen 7 1700X (Zen)	3/2/2017	$399	$389.99	$359.99
AMD Ryzen 7 1700 (Zen)	3/2/2017	$329	$314.99	$299.99
AMD Ryzen 5 1600X (Zen)	4/11/2017	$249	$239.99	$239.99
AMD Ryzen 5 1600 (Zen)	4/11/2017	$219.99	$214.99	$214.99
AMD Ryzen 5 1500X (Zen)	4/11/2017	$189	$189.99	$189.99
AMD Ryzen 5 1400 (Zen)	4/11/2017	$169	$164.99	$164.99
AMD A10-7890K (Godavari)	3/1/2016	$164.99	$134.99	$149.99
Intel Core i7-6950X (Broadwell-E)	5/31/2016	$1,723**	$1,695.00	$1,599.99
Intel Core i7-5960X (Haswell)	8/29/2014	$999**	$1,073.52	$1,073.52
Intel Core i7-6900K (Broadwell-E)	5/31/2016	$1,089**	$1,049.99	$1,034.99
Intel Core i9-7900X (Skylake-X)	6/26/2017	$999.99**	$1,061.99	$999.99
Intel Core i7-7820X (Skylake-X)	6/26/2017	$599.99**	$678.75	$599.99
Intel Core i7-6850K (Broadwell-E)	5/31/2016	$617**	$459.99	$359.99
Intel Core i7-7800X (Skylake-X)	6/26/2017	$389.99**	$415.99	$375.99
Intel Core i7-7740X (Kaby Lake-X)	6/26/2017	$349.99**	$349.99	$349.99
Intel Core i7-6700K (Skylake)	8/5/2015	$359**	$339.99	$339.99
Intel Core i5-7640X (Kaby Lake-X)	6/26/2017	$249.99**	$249.99	$239.99

* As of August 2017
** Manufacturer's estimated price per 1,000

New X399 Memory From G.SKILL

G.SKILL has released specs for new kits of DDR4 in the Flare X line that it created for AMD's Threadripper platform. The memory specs are optimized for motherboards sporting X399 chipsets and high-end Threadripper CPUs. The specifications are for 1.35V kits that run at frequencies from 2933MHz to 3600Mhz. There are two kit capacities: 32GB (8GB x 4) and 128GB (16GB x 8). The latter kit takes advantage of the eight memory slots that can run in quad-channel mode on AMD's X399 platform. G.SKILL says the 32GB 3600MHz kit of Flare X is the fastest memory kit that has been released for AMD's platform. The specifications for that kit as well as the other new kits are as follows:

FREQUENCY	TIMING	KIT	CAPACITY	VOLTAGE
3600MHz	16-18-18-38	32GB	(8GB x 4)	1.35V
3466MHz	16-18-18-38	32GB	(8GB x 4)	1.35V
3200MHz	14-14-14-34	32GB	(8GB x 4)	1.35V
2933MHz	14-14-14-34	128GB	(16GB x 8)	1.35V

CableMod Announces ModWrap

The ModWrap is a sleeving kit from CableMod that lets users dress up the cooling tubes used in AIO coolers. Custom loops often have transparent tubing, so enthusiasts can dye the color of the liquid to fit the color scheme of their systems. AIO liquid-cooling kits come pre-filled with liquid and generally have black tubing, which stylistically will work in most builds. With the ModWrap, users can give the tubing in AIO kits extra visual punch. The ModWrap sleeving is made of nylon and is custom fit for specific lines of coolers. The sleeving comes in your choice of five colors: White, Red, Light Blue, Light Green, and Carbon (the colors match the ones CableMod uses for its ModMesh cables). The kits come in two series: Series 1 kits work with Corsair's second-gen Hydro coolers, while Series 2 kits work with EVGA CLC coolers and NZXT Kraken models. CableMod says it may add sleeving kits for other cooler models if there is enough demand. The ModWrap kits are priced at $19.90.

Lian Li Goes Small With PC-Q39 WX

Lian Li's PC-Q39 WX is a small-form-factor tower that features a tempered-glass side panel on the left. The Mini-ITX case supports full ATX-sized power supplies and has slots for three graphics cards. The interior layout divides the chassis into two compartments, one that runs along the bottom for the power supply and storage drives, the other for the motherboard and graphics cards. The lower compartment holds a drive rack that can handle up to two 3.5-inch drives and one 2.5-inch drive. Another 2.5-inch drive can be placed in the back of the case, plus there is room for one more on the motherboard tray. The main compartment has room for graphics cards up to 320mm long and a CPU cooler up to 120mm. The chassis itself is made of aluminum and measures 348 x 252 x 346 (HxWxD in mm). The case has spots for up to four fans (2 x 120mm on top, plus 2 x 120mm or 1 x 140mm on the bottom). It also supports liquid-cooling radiators up to 240mm on top. The MSRP for the new PC-Q39 WX is $209.99.

Thermaltake Reveals Two New Views

Thermaltake's new View 71 TG and View 71 TG RGB are nearly identical towers, but they vary in the type and number of fans included with the cases. The View 71 TG has two preinstalled 140mm Riing Blue fans, while the View 71 TG RGB comes with three preinstalled 140mm Riing RGB fans. Other than that, the specs for the two cases look the same, with the same interior structure and 5mm tempered-glass panels on the front, top, and both sides. Both cases measure 592 x 274 x 577 (HxWxD in mm) and they each weigh a hefty 41.66 pounds. Inside, they have an HDD rack that holds four 2.5-inch or 3.5-inch drives, plus there are mounts for an additional six 2.5-inch or three 3.25-inch storage units. The cases support motherboards up to EATX, and they have 8+2 expansion slots. Graphics cards can range up to 410mm without the HDD rack, or 310mm with the rack. The CPU cooler has 190mm of headroom. Pricing wasn't available at press time, but by the time you read this, both cases should be available at retailers.

HARDWARE MOLE

HyperX Releases Kit For Gamers Who Want Keyboard Feedback

HyperX, the extreme gaming division of Kingston Technology, has released a keycaps upgrade kit. The kit is aimed at gamers who play MOBA or FPS games. The kit contains keycaps in your choice of two colors: red (HXS-KBKC1) or titanium (HXS-KBKC2). The caps are textured to give users more tactile feedback from their keyboard while gaming, plus they have a coating that gives them extra durability. Along with caps for the keys commonly used in MOBA/FPS games, the kit contains a HyperX keycap removal tool. HyperX says the replacement gaming keycaps are compatible with Cherry mechanical switches. MSRP for the new keycaps upgrade kit from HyperX is $14.99.

ADATA Unveils XPG SX9000 SSD

ADATA's fastest consumer SSD is on the way. The XPG SX9000 is an PCIe Gen 3x4 NVMe 1.2 SSD that uses the M.2 2280 form factor. ADATA is targeting the new drives at gamers and overclockers. The XPG SX9000 can read sequential data at up to 2800MBps and write at up to 1,450MBps. The drive uses MLC NAND and has a Marvell controller. ADATA says random 4K read/write speeds are 310K/240K IOPS. The new series ships with a black heat spreader that has the ADATA logo, but the company is leaving it up to buyers to decide whether they want to attach it to the drive. Thermal paste is pre-applied to the heat spreader to make the DIY installation as painless as possible. The exact availability date hasn't been released, but ADATA says the new drives will be available in 256GB, 512GB, and 1TB capacities.

The preview version of the new Hard Disk Manager 16 is here!

Paragon Releases Free Preview Version Of Hard Disk Manager 16

Paragon Software Group is getting ready to release the next commercial version of Hard Disk Manager, the company's suite of tools that helps you maintain your storage devices and protect your data. Version 16 of the software includes new features and utilities for partitioning drives, making and scheduling backups, and restoring data. Paragon says the latest version of the suite has an improved user interface that makes using the software more intuitive, and it includes a new Create Backup Job Wizard that speeds up the process of creating individual backups or scenario-based backups for your PC. Recently the company released a "free preview" version of HDM 16 at www.paragon-software.com to let users download and try out the new features with their storage devices. The preview version is completely free to use and there is no time-based cutoff, so it won't shut down in 15 or 30 days (note that it won't let you upgrade for free to later versions).

Skydance Interactive Announces $12.99 Release For PWNED FPS

Entertainment software publisher Skydance Interactive announced it is releasing the new game PWNED for Windows PCs via Steam Early Access. The company first debuted the game at Comic-Con in San Diego in July. The fast-action FPS game will only cost $12.99. SkyDance describes PWNED as an arena-based shooter that takes place in a "dystopian future" and says it features "three-dimensional rocket-jumping combat." Along with the low price point for PWNED, Skydance says users who buy the software in the first few days of September will receive special skins they can use in the game. Early purchasers also can participate in a contest to win prizes on the PWNED leaderboard. Skydance says it will award the best player on the board each day a new gaming computer (the special computer giveaway contest will run until September 3).
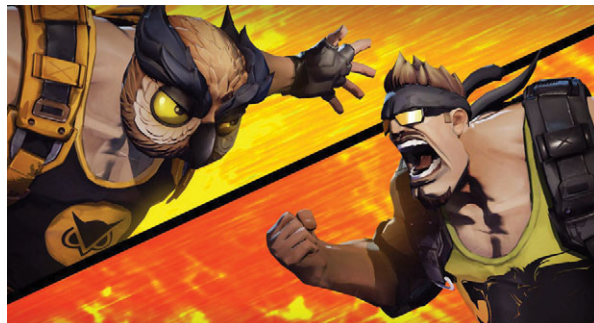
SOFTWARE SHORTS

Google Releases Android 8.0, "Oreo"

Google's Android operating system is now found on about two billion mobile devices worldwide. The latest version of the OS is called Oreo (or Android 8.0), and it is now available to the public. The update includes a number of new features. Google says Oreo boots twice as fast as previous iterations of Android (which also are named after various confections), and the redesigned interface gives users access to more apps with fewer taps. There's also a picture-in-picture feature that lets you see two apps at once. A menagerie of more than 60 new emojis is available to help people express themselves, and the autofill feature now works with passwords, so you can log into your favorite apps and websites faster. Google also has made a number of tweaks that it says improve the battery life of mobile devices and also increase user security. You can learn more about all the new features by visiting www.android.com.

Google Adds Q&A To Maps & Search

Google is adding a new question-and-answer feature to Maps and mobile Search. The Q&A feature lets users post questions at the bottom of business listings that appear on Maps or in Search when someone looks for a type of company by location (say, restaurants in Seattle or museums in Cleveland) or a particular business by name. The listings show information about the company and give a street address and other contact information. At the bottom of the listing, the new Q&A feature will let users post a question about the business or institution (Do you serve gluten-free meals? What's the best time to visit this exhibit?) and then someone from the business or other users can post answers. Users who post a question will receive a notification when somone posts an answer. Users will be able to scroll through questions other people have asked and "upvote" or "downvote" them, so the most useful information will appear toward the top of the questions list. Businesses also will be allowed to create a sort of FAQ list by asking and answering their own questions.

## Mozilla's New Firefox 55 Browser Supports WebVR Standard

Mozilla, the non-profit organization that supports and promotes open-source technologies and products, has released an updated version of the Firefox web browser. Firefox 55 is the first Windows desktop browser that supports WebVR, the standard that was created to allow people to experience virtual reality programs with just a browser and a headset. In addition to being able to view virtual reality content, Firefox 55 has been tweaked in various ways to improve performance and usability. The address bar includes predictive search suggestions and a one-click search function. Version 55 also prioritizes authenticated addresses (sites using the HTTPS protocol instead of just HTTP) for more secure Internet browsing. Other new features include changes to make pages load faster and to improve battery life in portable devices.
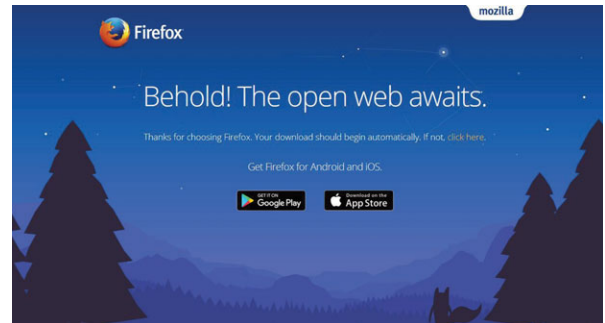
SITE SEEING

So You Think You Know The Internet

The PIR, or Public Interest Registry, is the non-profit entity that handles registration for the .org domain and a few others. PIR recently conducted a nationwide survey of internet users to find out how much they really know about the network. It turns out, not so much. For starters, only 20% of respondents knew that the World Wide Web and the internet are two different things. A slightly higher percentage (29%) knew what the abbreviation HTTP stands for. Only 31% could define what the DNS does, and barely 32% even know what decade the web began. The results are a little confounding, especially when you consider the average respondent had been using the internet for 17 years (!). For information on the survey and a link to a graphic that illustrates some of the survery results, see http://pir.org/internet-101-survey-how-much-do-people-really-know-about-the-internet/.
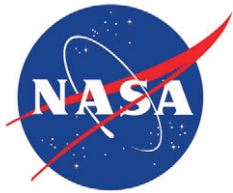
Job Of The Month

Got the right stuff? OK, so we're really not talking about applying for an astronaut position here, but it *is* a position with the same parent organization. NASA employs thousands of people in STEM positions (hey, they practically invented the pocket protector), and they are currently looking for an Information Technology Specialist (Data Management) for their offices at the Langely Research Center in Hampton, Va. This person will help capture data, classify data, integrate data, manage data, model with data, analyze data . . . well, you get the idea. You'll be a doing lots of stuff with data. The ideal candidate will be experienced with data analytics techniques and know all about data modeling and data standardization procedures. The IT Specialist, Data Management works closely with other IT and engineering teams at NASA. You won't be walking on the moon (they say it's not a remote working position, anyway), but who knows, you may end up meeting some folks who do. Hey, it's NASA! See the site below for more info.

Source: www.usajobs.gov

Three Letters: M.I.T.

The Center For Data Innovation, a global think tank that examines public policy as it pertains to technology and data, recently released a report that ranked all 50 U.S. states on how well-prepared they are to participate in tomorrow's data-driven economy. The report examined 25 indicators in three key technology asset categories: 1) availability of datasets (in areas such as energy, education, health care, and so on); 2) technology (how well the state is doing in developing broadband access and other digital infrastructure); and 3) people and companies (whether a sufficient pool of data professionals is available and how many technology-based companies are already in the state). The results of the report show Massachussetts is well positioned for the future, while Mississippi has some catching up to do.
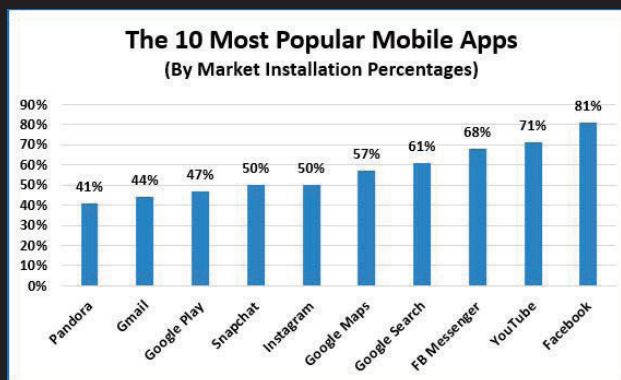
Source: Center For Data Innovation

Rank	State	Score	Rank	State	Score
1	Massachusetts	63.0	26	Florida	41.0
2	Washington	60.4	27	Missouri	40.8
3	Maryland	59.2	28	New Hampshire	40.0
4	California	57.1	29	Nebraska	39.4
5	Delaware	56.9	30	Nevada	38.4
6	Utah	56.4	31	Iowa	37.4
7	Virginia	55.9	32	North Carolina	37.3
8	Oregon	55.7	33	Kansas	35.5
9	Colorado	54.2	34	Tennessee	34.5
10	New York	53.3	35	Oklahoma	33.7
11	Minnesota	50.3	36	Kentucky	32.7
12	Illinois	48.7	37	Hawaii	32.4
13	Texas	48.7	38	Arkansas	32.3
14	Vermont	47.0	39	New Mexico	29.9
15	Michigan	47.0	40	Idaho	29.6
16	Pennsylvania	46.2	41	Alaska	29.3
17	Indiana	46.1	42	North Dakota	29.0
18	Connecticut	45.2	43	South Dakota	26.1
19	Rhode Island	44.4	44	Montana	25.8
20	Maine	44.3	45	Wyoming	25.7
21	Georgia	43.9	46	South Carolina	22.5
22	Ohio	42.7	47	Alabama	22.3
23	New Jersey	41.7	48	Louisiana	21.8
24	Arizona	41.5	49	West Virginia	19.2
25	Wisconsin	41.4	50	Mississippi	18.9

Facebook & Google: Yes, They Do Own The World

Modern consumers spend a great deal of time on digital media, and 57% of that time is spent on mobile apps. Even when you take tablets out of the equation, smartphone apps still account for more than half our digital media time. According to research by comScore, seven apps have now achieved 50% or more market penetration (installed on more than half of the devices that use mobile apps). Facebook leads the pack with 81%, with Google's YouTube in second place with 71%. In fact, Facebook and Google own eight of the 10 most popular apps.

Source: comScore

The 10 Most Popular Mobile Apps
(By Market Installation Percentages)

Pandora 41%, Gmail 44%, Google Play 47%, Snapchat 50%, Instagram 50%, Google Maps 57%, Google Search 61%, FB Messenger 68%, YouTube 71%, Facebook 81%

RAW Numbers:

1,388+

The collective equivalent time in years that all of humanity spends entering passwords into digital devices each day. This estimate by Microsoft Principal Researcher Dr. Cormac Herley assumes two billion people enter an average of one password per day. And that number has no doubt grown significantly, as Herley's original calculation was based on data from 2014.

Cormac Herley, "Passwords: A Guide To The Ruins And Lessons For Improvement"

24 million

The number of households worldwide that will own at least one virtual reality device by the end of 2017.

Parks Associates

256 million

The number of people worldwide who will be using virtual reality devices by the year 2022. This forecast also projects annual VR revenues in the U.S. alone will top $60 billion in five years.

ABI Research

$237 billion

The total revenues of the robotics industry worldwide by the year 2022. This total includes such items as autonomous vehicles, consumer robots, enterprise robots, and unmanned aerial vehicles. Total revenues from these categories in 2016 reached $31 billion.
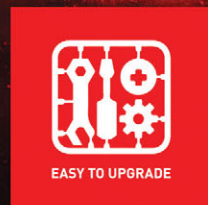
Tractica

InFinite A
GAMING DESKTOP PC

GAMING NEVER STOPS

The best Windows ever for gaming. | Windows 10 Home | Intel® Core™ i7 Processor | MSI® GeForce® GTX 1080 Graphics card

TRUE GAMING

Mech Warriors
We Put Thirteen Mechanical Keyboards To The Test

As a group, enthusiasts tend to upgrade their hardware at a faster pace than Joe and Jane PC User. If you want to play the latest and greatest games or power through a heavy workload in no time, you have to have a beefy graphics card, powerful CPU, smoking-fast SSD, and so forth. Plus, who doesn't love the excitement of jamming brand-new components into their rig? It's our way of life.

However, whether you're upgrading an existing system or building a new one from the ground up, we tend to pass over certain parts despite the promises we make to the contrary. If the mouse keeps clicking and tracks true, we tell ourselves that we'll replace it next time. Why worry about a handful of dead or stuck pixels when your monitor has millions more that work perfectly? And of course, unless you've created a Mountain Dew swamp within your keyboard, most of the time it will keep right on typing.

If you're still forcing your fingers to toil away at a decade-old keyboard, maybe the time has come for you to think about swapping it for a newer model. This isn't always true, as high-quality mechanical keyboard can stand up to years of punishment. But it's precisely for that reason we've assembled a small army of mechanical keyboards for this roundup. The mushy $15 keyboard in front of you is doing you no favors. Make the move to mechanical and don't look back. Instead, look at all these awesome options; one of them will be your next keyboard.

Hooked On A Feeling

We've been preaching the benefits of mechanical keyboards for years, but if you're new to the game, here are the CliffsNotes. For starters, the keyswitches that mechanical keyboards use are far more durable and long-lasting than keyboards with rubber dome or membrane switches. Further, with a little practice, you can use mechanical switches' characteristics to make typing easy, fast, and effortless. To wit, clicky and tactile keyswitches give you both aural and haptic cues, respectively, to type without bottoming out the keys as you go. Eventually, you'll be typing up a storm and wondering why you spent the best years of your life using a substandard keyboard.

Despite the general advantages of mechanical keyboards, we don't recommend haphazardly buying one. Clicky keyboards, for example, are music to some users' ears but a cacophonous nightmare to others. If you can't stand the sound, you'll want a mechanical keyboard with silent, or non-clicky, switches. We recommend taking a mechanical keyboard or two for a test drive; take advantage of your next LAN party, or if your friend(s) have one, take advantage of them. After chronicling the adventures of the quick brown fox and its jumps over lazy dogs a few times, you'll know the type of mechanical switch for you.

In a similar vein, when we review a mechanical keyboard, we keep our personal preferences (see above: cacophonous clicky switches) in check and evaluate each board on its individual merits. If we feel like a manufacturer has product a brilliant keyboard with Blue or Green switches, we'll assess it as such.

Cherry MX BOARD 6.0

Leading off our roundup is the keyboard from the company that's arguably responsible for the modern resurgence of mechanical keyboards among enthusiasts. After watching other companies succeed on the back of its incredibly popular MX keyswitches, German designer Cherry delivers its own keyboard, the MX BOARD 6.0. If you've always wondered what Cherry's vision of the quintessential MX-based keyboard might be, wonder no longer.

As far as construction goes, the MX BOARD 6.0 is practically peerless. Sleek and stately, the chassis is a combination of aluminum and plastic, like the majority of

MX Board 6.0
$175.99　|　Cherry　|　www.cherry.de

Specs: Switch type: Mechanical (Cherry MX Red); 50 million keystroke life span; Interface: USB; Red LED lighting; Full anti-ghosting; Full n-key rollover; Macros: N/A; Warranty: 2 years

CPU RANKING　　0 = ABSOLUTELY WORTHLESS　　2.5 = ABSOLUTELY AVERAGE　　5 = ABSOLUTELY PERFECT

MasterKeys Pro S

$79.99 | Cooler Master | www.coolermaster.com

Specs: Switch type: Mechanical (Cherry MX Green); 50 million keystroke life span; Interface: USB; Macros: Yes; Full anti-ghosting; Full n-key rollover; Warranty: 2 years

our boards, but Cherry's execution is a sight to behold. In addition to its clean lines, the MX BOARD 6.0 had absolutely no flex to it. Even the wrist rest, which attaches magnetically, is luxurious. Measuring a little over 3.5 inches deep and coated with soft-touch rubber, the wrist rest is a terrific complement rather than an afterthought. The MX BOARD 6.0's LEDs shine through its keycaps more brightly than any of the other keyboards we tested. If you want proof that elegance doesn't have to be elaborate, Cherry's keyboard is exhibit A.

Similarly, it's no great surprise that the MX Reds work flawlessly. These switches aren't generally regarded as the best switches for general-purpose typing, and in truth we prefer our keys to at least offer a tactile response. That said, the MX BOARD 6.0 arguably has the best feel of any mechanical keyboard that uses Red switches. As such, it has the speed that hardcore gamers are looking for in a mechanical keyboard without delivering substandard results while writing a term paper or the next Great American Novel.

But as good as the MX Reds are in the MX BOARD 6.0, it doesn't change the fact that many people would rather use MX Browns, Blues, Blacks, or one of the other

colors in Cherry's palette. Curiously, Cherry makes no other variants of the MX BOARD 6.0, so even if you've fallen in love with the look, you might have to persuade yourself into having a similar affection for the Red switches. As the company that actually makes

its keyboard's switches, Cherry's decision not to offer the MX BOARD 6.0 with alternate switches is somewhat puzzling

Also puzzling is the extent of the MX BOARD 6.0's options, which are rather limited. As we said, the red LEDs' brightness is outstanding, but brightness is all you get— no custom colors or effects, no macros, no software. Another conundrum is that the MX BOARD 6.0's Red switches are probably the best fit for gamers and yet the keyboard has none of the goodies they want.

As "just a keyboard," the MX BOARD would be damn near perfect, but we know there's no such thing as "just a keyboard" anymore. An ultra-premium price is fine, but the feature set has to match. If "the perfect MX Red experience" and nothing else is on your wish list, take a look.

Cooler Master MasterKeys Pro S

Lately, we've noticed a trend among keyboard manufacturers toward full-flavored flash. We're talking about RGB LED lighting—the more the better. Now that virtually every other system component has embraced LEDs, these keyboards fit right in. Cooler Master's MasterKeys S course-corrects.

K95 RGB PLATINUM

$199.99 | Corsair | www.corsair.com

Specs: Switch type: Mechanical (Cherry MX Brown); 50 million keystroke life span; Interface: USB; Macros: Yes (6 dedicated keys); Per-key RGB backlighting (16.8 million colors); Full anti-ghosting; Full n-key rollover; Warranty: 2 years

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

Perfect for minimalists, the MasterKeys S is one of two keyboards in our roundup to feature a tenkeyless design. In other words, Cooler Master lopped off the numeric keypad, making this keyboard considerably smaller than its compatriots. (If you want the numpad back, the MasterKeys L is your ticket.) As such, the MasterKeys S follows in the tradition of Cooler Master's other tenkeyless boards, such as the QuickFire Rapid. At 2.13 pounds, the MasterKeys S has a little heft, but it didn't feel cumbersome.

Cooler Master touts the MasterKeys S' durability, and we buy it. The plastic frame is exceptionally rigid; we'd have no reservations about flinging this keyboard into a backpack for transport to a LAN party. Cooler Master uses PBT keycaps that are 1.5mm thick, or nearly twice as thick as most ABS keycaps. After pulling off one of the keycaps and comparing it to a couple of others, the MasterKeys S' keycaps do feel slightly more rigid. Keycap breakage does happen from time to time, so the 1.5mm-thick keycaps (the included red replacement WASD—plus Q, E, and R—keycaps don't appear to have the same thickness) are a non-negligible benefit.

The MasterKeys S that Cooler Master sent us used Cherry MX Greens, clicky and tactile switches that are even stiffer than MX Blues. The Greens will give your fingers a workout, but their implementation on the MasterKeys S will be immensely satisfying for anyone who prefers a firmer feel. Don't fret if you favor a lighter touch, as Cooler Master also makes the MasterKeys S with MX Blue, Red, Brown, or Silver switches.

There's no software for the MasterKeys S, which is a benefit or a drawback depending on how you use your keyboard. Macro maniacs may need a little more than the MasterKeys S' onboard capabilities. That said, this is a no-nonsense tenkeyless board that can take a punch.

Corsair K95 RGB PLATINUM

Corsair has never been a company that cuts corners. Even its wares made for thrifty enthusiasts have terrific fit and finish and attention to detail. So naturally, Corsair's flagship mechanical keyboard, the K95 RGB PLATINUM, arrived on our doorstep dressed to impress. Spoiler: We were impressed.

Our K95 included Cherry MX Brown switches, which are among Cherry's lightest and fastest switches, requiring a mere 45cN to actuate. This puts them on par with Cherry MX Reds (you might refer to them as the "gamer switches"), but the Browns also have a tactile bump that makes them more suitable as an everyday board. Alternatively, Corsair offers the K95 with Cherry MX Speed switches, a relative newcomer that's even more similar to the Reds. (The biggest difference is travel distance—2mm for MX Red switches vs. 1.2mm for the Speeds.) Of course, the Browns as Corsair has implemented them on the K95 are excellent, solid all-around performers but also fast enough to lead you to victory in your favorite game(s).

Corsair is obviously aware that the K95 will be the weapon of choice for many gamers and designed the keyboard as such. The column of six macro keys on the left edge of the keyboard are texturized (as is the Spacebar), and Corsair also includes extra sets of texturized keycaps that match popular game layouts (FPS and MOBA). A magnetized wrist wrest would have been nice, but the wide strip of soft-touch rubber that Corsair uses is quite comfortable. An aircraft-grade aluminum backplate runs from top to bottom of the K95, and the contours

HEAVY GEAR
4.0 OUT OF 5
CPU

Attack X3
$109.99 | COUGAR | www.cougargaming.com

Specs: Switch type: Mechanical (Cherry MX Speed); 50 million keystroke life span; Interface: USB; Macros: Yes; Per-key RGB backlighting (16.8 million colors); Full anti-ghosting; Full n-key rollover; Warranty: 1 year

Francium Pro
$164.99 | Deck | www.deckkeyboards.com

HEAVY GEAR
3.0 OUT OF 5
CPU

Specs: Switch type: Mechanical (Cherry MX Brown); 50 million keystroke life span; Interface: USB; Macros: Yes; White LED backlighting; Full anti-ghosting; Full n-key rollover; Warranty: 1 year

are undoubtedly attractive. Although the aluminum itself was sturdy, the plastic portion of the body did flex slightly.

Put "RGB" in your keyboard's name, and you'd better be prepared to deliver, especially if that keyboard will separate potential buyers from a pair C-notes. Thankfully, this isn't a concern with the K95, thanks to a combination of bright LEDs and truly great software, the Corsair Utility Engine. In addition to giving you a great deal of control over the LEDs' color (per-key lighting, natch), speed, and

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

so forth, CUE connects to certain other Corsair components and unites them, as the company has slowly made good on the promises it made with Corsair Link so long ago. You can also download additional community-generated effects. As good as the lighting aspect of CUE is, its macro controls are arguably better, and the clean UI makes Corsair's software accessible and powerful in equal measure.

The K95 RGB PLATINUM is an outstanding example—maybe the best example—of what a Cherry MX mechanical keyboard with customizable RGB LED lighting can be. That much is undeniable. On the other hand, Corsair doesn't hold a monopoly over LEDs or Cherry switches. Corsair's K95 RGB PLATINUM gives you a lot, but for 200 bucks, it's asking a lot in return.

COUGAR Attack X3 RGB

In this business, a proper show of force can be the difference between a product going gangbusters and gathering dust in an online retailer's warehouse. You don't think brags like "aggressive design" and "Starfleet-grade components" happen by accident, do you? Well, if you need your stuff to be threatening, you can shut things down right now. We have a keyboard from a company whose namesake is one of North America's premier apex predators, and its product name is "Attack" . . . times three!

Let's get serious, though, because COUGAR's redesigned Attack X3 RGB is one cool cat. It's one of two keyboards in this roundup to use Cherry's MX Speed (aka Silver) keyswitches. Notice again that show of force, this time from Cherry: MX Speed switches are fast, and gamers love fast. Specifically, these linear switches have an actuation force of 45cN, putting them on equal footing with Cherry's other "fast" switch, the MX Red. The key difference between the two is the Speeds' slightly lower travel distance of 1.2mm. (A Red switch has 2mm actuation point.)

Despite their profile, the MX Speed switches on the Attack X3 RGB feel closer to Cherry's other linear switch, the MX Black. This keyboard has a light touch, to be sure; it's most definitely a gamer, and we liked its overall performance. We even prefer the Attack X3 RGB's switches over MX Reds for general-purpose typing. COUGAR also offers the Attack X3 RGB with MX Red, Black, Brown, or Blue keyswitches, but you won't get the detachable wrist rest that this new model includes.

COUGAR sticks with a tried-and-true combination of brushed aluminum and plastic for the Attack X3 RGB's chassis. The finish is subdued, without much luster, but the Attack X3 RGB is still a sleek board. COUGAR reports a weight of 2.2 pounds; despite this, we thought the keyboard was reasonably sturdy. With a gentle twist, the plastic part of the Attack X3 RGB's chassis wanted to pull away where it met the aluminum, but the aluminum itself was rock-solid.

The UIX System that COUGAR has developed to fully harness the Attack X3 RGB's capabilities is arguably as good as the keyboard itself. COUGAR gives you plenty of dials and knobs to turn. In addition to flipping the On switch to activate the typical set of lighting effects (ripple, wave, reactive—you know the drill), you can drill down and customize the effects. The UIX System also handles macro recording and profile creation. To make matters better, we liked the UI's aesthetic, as well.

Available for $109.99, COUGAR's new Attack X3 RGB is an awesome, approachable keyboard for gamers seeking their first mechanical keyboard, but it's also an intriguing option for MX Red veterans who want to give the Speeds a shot. If you bag this big cat, you won't be disappointed.

Deck Francium Pro

Most of the companies featured in this roundup dabble in all sorts of product categories. Deck makes keyboards and only keyboards. (And Deck comes by it honestly, as parent company TG3 Electronics produces specialized keyboards for a wide range of industries—think hospitals, emergency vehicles, POS devices, and more.) For this tenkeyless mechanical keyboard, Deck turned to the periodic table to give us the Francium Pro. See, everyone's fourth-favorite alkali metal (apologies to rubidium and cesium) has an atomic number of 87. Want guess how many keys the Francium Pro has?

Beneath the Deck's keycaps are Cherry MX switches. Our Francium Pro had MX Browns, which have the same fast and light action as the MX Red switches, requiring 45cN to actuate, but they also have an accompanying tactile bump. As a result, the Francium Pro is an outstanding all-around keyboard, provided you don't have any qualms about ditching the numpad. We thought the keyboard was fast and responsive, a great example of the MX Brown switches in action.

AORUS K7
$129.99 | GIGABYTE | www.aorus.com

HEAVY GEAR
3.5 OUT OF 5
CPU

Specs: Switch type: Mechanical (Cherry MX Red); 50 million keystroke life span; Interface: USB; Macros: Yes; Per-key RGB backlighting (16.8 million colors); Full anti-ghosting; Full n-key rollover; Warranty: 2 years

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

Design-wise, the Francium Pro is a string of hits and one glaring swing-and-a-miss. Beneath the plastic exterior is a metal frame that must be made out of vibranium, because this keyboard didn't give an inch when we tried to twist the body. Deck then doubles down on durability, topping the switches with thick PBT keycaps. In addition to their resilience, the PBT keycaps are highly resistant to fingerprints. Because of the keycaps' thickness, though, we didn't think the Francium Pro's LEDs had quite the shine as many of the other keyboard in the roundup, but that's not its greatest offense. Rather than stick with a plain, but inoffensive font for the keycaps, Deck chose something that resembles the cover of a children's fantasy novel. Perhaps Deck was hoping to distinguish the Francium Pro from other tenkeyless mechanical keyboard. Mission accomplished, but not in the way the company likely intended.

Instead of the 16.8 million colors some companies' keyboards boast, Deck gives you two. You can get a Francium Pro with either blue or white LEDs. And even though you can customize those monochromatic LEDs in any pattern you please, be prepared to do a lot of the legwork. Rather than give you a utility with a GUI, you'll have to roll up your sleeves and script the lighting effects yourself (or cheat and download some from sites dedicated to mechanical keyboards). If that sounds daunting, Deck doesn't leave you completely high and dry, as a handful of lighting effects are built into the Francium Pro.

All of this makes Deck's tenkeyless dynamo a bit of a mixed bag. It's tough as nails, make no mistake, and the Cherry MX Brown switches are terrific. Despite selling online at a deep discount ($94),

RIPJAWS KM780 RGB
$169.99 | G.Skill | www.gskill.com

Specs: Switch type: Mechanical (Cherry MX Brown); 50 million keystroke life span; Interface: USB; Macros: Yes (6 dedicated keys); Per-key RGB backlighting (16.8 million colors); Full anti-ghosting; Full n-key rollover; Warranty: 2 years

if you want easy access to lots of LED patterns and colors, there are other choices that might serve you better.

GIGABYTE AORUS K7

As more companies establish and develop gaming brands, GIGABYTE has answered with its AORUS family. In addition to the usual suspects, the AORUS line has a wide range of components, such as mice, a CPU cooler, and even a gaming chair. Joining the gang is the AORUS K7, a mechanical keyboard with virtually wall-to-wall LED lighting.

In terms of physical design, the AORUS K7 is sleek and sensible. GIGABYTE uses a thin sheet of brushed aluminum for the top of the keyboard's frame. Just a shade or two lighter than gunmetal, the gray color has a slightly lustrous finish that nonetheless remained relatively free of fingerprints. The rest of the housing is plastic, and because GIGABYTE keeps the dimensions of this board to absolute minimum it doesn't quite have the same firmness as some of the other keyboards we tested. We'll also give credit where it's due: The AORUS K7's adjustable feet (we first thought the adjustment wheels at the top of the keyboard were dueling

volume controls) are a nice touch.

As far as other touching is concerned, Cherry's MX Red is the switch of choice on the AORUS K7; at the time of this writing, Blues or Browns weren't an option. We can't fault GIGABYTE for tapping the switch that's exceedingly popular among gamers to use in a keyboard it intends to market to gamers, but anyone who favors tactile and/or clicky switches must look else-where. There were no surprises from the AORUS K7's Reds. The switches are fast and smooth—this is can't-miss performance if you need a rapid-fire response in your game of choice.

Rather than use a standalone program to command the AORUS K7's LEDs, the AORUS GRAPHICS ENGINE gives you the tools. Naming aside, the move makes a lot of sense. As much as we grouse about ecosystem lock-in, we'd much rather have a single tweaking and tuning utility running the show if we're using hardware from a single manufacturer. (And to be clear, the software absolutely works with the AORUS K7 even if it's the only GIGABYTE component you own.) The UI won't win any beauty pageants, but it makes setting up the AORUS K7's per-key lighting far easier than relying on the onboard controls (which are decent in their own right). THE AORUS GRAPHICS ENGINE lets you create macros, too.

In short, the AORUS K7 is another fine offering from GIGABYTE's gaming lineup, this time in keyboard form. "By the numbers" often gets a bad rap; in this case, GIGABYTE has given us a solid Cherry MX

Red keyboard that won't take too big of a bite out of your wallet.

G.Skill RIPJAWS KM780 RGB

G.Skill wasn't the first company to realize the potential of mechanical keyboards among gamers and other enthusiasts, but the company's understanding of this audience is the reason why a keyboard like the RIPJAWS KM780 RGB is a powerful competitor.

Like the company's memory modules of the same name, there's no mistaking the RIPJAWS KM780 RGB. G.Skill clearly wanted to make a keyboard that would appeal to the FPS/MOBA/RTS crowd, and it went all in aesthetically. The KM780 RGB is not a keyboard you can sneak into the office, and that's a badge of honor as far as we're concerned. In addition to the anodized, brushed-aluminum backplate, G.Skill rings the periphery of the KM780 RGB with what amounts to a roll cage. The end result is a keyboard that doesn't give an inch in terms of durability, but it does result in one of the largest footprints of the keyboards we tested. For our tastes, it's a great-looking keyboard.

The Cherry MX Brown switches our KM780 RGB uses (G.Skill alternatively lines the RIPJAWS KM780 RGB's maw with Red and Blue choppers, as well) are a delight. Requiring 45cN of force to actuate and offering a tactile bump, the Browns have the same light touch

for gaming as the Reds, but the haptic response makes them a little more suitable for everyday use. The switches performed admirably on the KM780 RGB, offering exactly the feel we expect from an MX Brown. The column of six dedicated macro keys on the keyboard's left edge is relatively easy to reach. The volume barrel located in the top right corner has a smooth, but not loose feel. G.Skill jacks the KM780 RGB's "gamer look" to the max, but make no mistake—the function matches the form.

Fire up the RIPJAWS KM780 RGB's software, and you'll find that it's of the same caliber as the keyboard itself. It lets you drill down and configure nearly every little thing on the KM780 RGB. In addition to standard roster of macros, profiles, and lighting effects, you can tweak individual key lighting and the effects themselves. Creating a custom lighting profile does take a lot of work, but G.Skill's software makes it possible, even if newcomers might find it a bit daunting.

Don't let the RIPJAWS KM780 RGB's $169.99 MSRP scare you. You should be able to find it online priced well south of that mark. It possible that the keyboard's distinct look might limit its broad appeal, which is a shame, because G.Skill has demonstrated it can trade punches with the industry's heavyweights.

HyperX ALLOY Elite

HyperX's bread and butter has always been its high-end DRAM, but the company's pantry is stocked with plenty of other ingredients to help give gamers a competitive edge. In addition to the stacks and stacks of blazing-fast system memory, HyperX (quick reminder: the company is still under Kingston's tent, even though Kingston has made an effort to establish HyperX as a distinct brand) also makes solid-state drives, mice, headsets, and a few additional
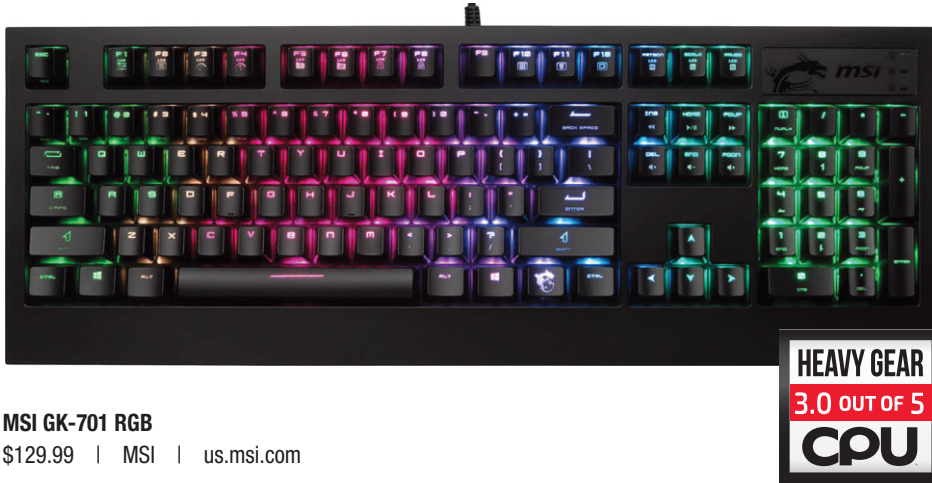

ALLOY Elite
$109.99 | HyperX | www.hyperxgaming.com

Specs: Switch type: Mechanical (Cherry MX Red); 50 million keystroke life span; Interface: USB; Macros: Yes; Red LED backlighting; Full anti-ghosting; Full n-key rollover; Warranty: 2 years

G413 Silver
$89.99 | Logitech | gaming.logitech.com

Specs: Switch type: Mechanical (Romer-G); 70 million keystroke life span; Interface: USB; Macros: Yes; White LED backlighting; Full anti-ghosting; 26-key rollover; Warranty: 2 years

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

MSI GK-701 RGB
$129.99 | MSI | us.msi.com

HEAVY GEAR
3.0 OUT OF 5
CPU

Specs: Switch type: Mechanical (Cherry MX Speed); 50 million keystroke life span; Interface: USB; Macros: Yes; RGB LED backlighting (16.8 million colors); Full anti-ghosting; Full n-key rollover; Warranty: 1 year

odds and ends. Its flagship keyboard is the ALLOY Elite.

As far as switch selection goes, where a lot of manufacturers zig, HyperX . . . also zigs. Of course, when zigging involves using Cherry MX mechanical switches, that's not a knock. Our ALLOY Elite had MX Red switches (no bumps, no clicks), but HyperX also produces the keyboard with the other two "Big Three" Cherry switches—MX Blues and MX Browns. Red switches are often pigeonholed as the "gamer switches," people who like easy, breezy typing should find the switches on the ALLOY Elite to their liking. Sure, it's not groundbreaking, but using the ALLOY Elite was exactly what we'd expect from an MX Red keyboard.

A mix of plastic and steel make up the ALLOY Elite's body, and the end result is, for the most part, a relatively sturdy keyboard. If that sounds like we're hedging, we are. The top "bar" of the ALLOY Elite, where the LED and media keys are located, appears to be entirely plastic. To be fair, we suspect this would only become a problem if you used the ALLOY Elite in a cage fight, but it also gives the keyboard a slightly less than premium air. That said, HyperX included a detachable wrist wrest that's treated with a sweet, soft-touch coating that we're suckers for. You also get a small bundle

of replacement keycaps; the set consists of WASD and 1-4 keycaps. All of the alternate keycaps are titanium-colored, and the WASD keycaps are texturized.

The LED lighting on the ALLOY Elite is a bit on the basic side. We'll admit that sometimes choosing from 16.8 million possible colors and dozens of wacky effects can be, at times, exhausting, but there's a very real danger of going underboard and not giving enthusiasts as much as they've come to anticipate. The ALLOY Elite's red LED lighting is decent, but it's also the only available color. Similarly, the limited number of lighting effects all deliver as expected while simultaneously leaving any and all games unchanged.

Over the years, Kingston has made consistently good hardware under its HyperX label, and the ALLOY Elite is no exception. There are no huge surprises, good or bad, and we need keyboards like that. You can bring the ALLOY Elite home to mom and dad, and we guarantee you they'll approve.

Logitech G413 Silver

Of all the manufacturers with a hat in this ring, Logitech is the only one we'd consider a household name. The company has been making keyboards—high-end, budget-friendly, gaming,

etc.—for ages. Despite its long history in the market, Logitech has watched as a horde of others recognized the runaway popularity of mechanical keyboards and flooded the market with contenders, and most of them use battle-tested and enthusiast-respected Cherry MX switches.

To beat back the horde of other mechanical gaming keyboards, Logitech equips the G413 Silver with exclusive Romer-G mechanical switches. Produced with an assist from Omron, the Romer-Gs are quiet, tactile switches that closely resemble Cherry MX Browns. According to Logitech, its switches have a shorter actuation point—1.5mm—than Cherry's Brown switches. We've typed our way through several Cherry-based boards with switches of every color; the Romer-G switches have an undeniably different feel. Is it better than, say, the MX Browns? We felt like the Romer-G switches were a touch firmer than comparable Cherries, but again, it's largely a matter of preference. Less a matter of preference was the fact that the G413 Silver's Spacebar was noticeably noisier than its counterparts with Cherry switches. On the whole, though, we enjoying using the keyboard.

Credit Logitech with points for the G413 Silver's construction, too. The base of the keyboard is plastic, but the backplate is sleek brushed aluminum (5052 aluminum-magnesium alloy, to be precise). The aluminum lends a welcome degree of rigidity to the overall frame, and yet the G413 Silver didn't seem overweight when we held it. The keycaps do collect fingerprints like an episode of CSI, if that's a concern. Logitech also includes a set of WASD (plus QER and 1-5) replacement keycaps, and they're contoured differently rather a different color. We can see the benefit of being able to distinguish and locate the most important keys in the heat of battle, but the keycaps didn't revolutionize our experience, either.

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

To fully harness the G413 Silver's capabilities, you'll need to download Logitech Gaming Software. On this keyboard, LGS' principal role is configuring macros (and Logitech supplements this by giving you access to literally hundreds of game-specific profiles), mostly because the monochromatic LEDs have a single effect: breathing. One neat surprise was LGS' ability to record and display heatmaps of your most frequently pressed keys, something competitive gamers will likely appreciate. Otherwise, LGS as it works with the G413 is simple and straightforward.

Logitech arguably took a big risk by developing its own switches instead of jumping on the Cherry train. We think the gamble has paid off, especially when you consider the G413 Silver can be yours for 90 bucks. That's a steal. If you're not married to Cherry, let the Romer-G switches win your heart.

MSI GK-701 RGB

Over the last few years, MSI has a made a concerted effort to establish itself as the first name in gaming. Graphics cards, motherboards, laptops, you name it—if videogames are at the top of your to-do list, MSI makes it painfully easy to find hardware that's up to the task. The company has extended its reach to peripherals, too, with gaming mice, monitors, and keyboards (obviously).

Like most of the keyboards in the roundup, the GK-701 RGB makes ample use of LED lighting. No, all that flash won't make you a better gamer, but you'll look good doing it. You'll have 20 animations at your disposal, plus the ability to adjust LED color and intensity. However, without a utility to manage the GK-701 RGB's customizations, the process can be somewhat of a chore. Further perplexing is the fact that MSI's Mystic Light software works with other manufacturers' keyboards but not the GK-701 RGB. On balance, though, the GK-701 RGB's LEDs have a nice glow; because the keys are nestled within a fairly deep frame, the shine is a little

subdued. Speaking of that frame, the GK-701 RGB has a plastic body. Overall, the frame has some flex, but at the same time it doesn't feel flimsy. The matte finish did pick up a fair number of fingerprints as we used it.

MSI presents you with a single choice of Cherry MX switch if you want the GK-701 RGB, but we suspect gamers with itchy trigger fingers will appreciate it. The Cherry MX Speed switches are the lightest of Cherry's offerings and comparable to the MX Reds. Both silent,

linear switches have an actuation force of 45cN, but as you'll recall, the Speeds have a slightly shorter actuation point, just 1.2mm. Typing on the GK-701 RGB is indeed effortless, and we suspect gamers will like this APM monster.

Overall, the GK-701 RGB is a great way for gamers and other enthusiasts to get a fast mechanical keyboard with solid LED lighting. Mystic Light compatibility would've been a terrific treat for MSI loyalists, and which makes this keyboard just a little less delectable than it could've been.

Patriot Viper V770

As soon as a particular type of component picks up steam among enthusiasts, you can expect Patriot to arrive on the scene in short order, offering its own unique take. Most of us know that Patriot was among the first to introduce high-performance memory modules, and over the course of the company's three-decade history it's done the same thing for lots of other hardware. Patriot's Viper line of gaming peripherals is yet another example.

Viper V770
$139.99 | Patriot | patriotmemory.com

HEAVY GEAR
4.0 OUT OF 5
CPU

Specs: Specs: Switch type: Mechanical (Kailh Red); 50 million keystroke life span; Interface: USB; Per-key RGB backlighting (16.8 million colors); 109-key rollover; Macros: Yes (5 profiles); USB pass-through port; Game mode; Warranty: 2 years

You'll regularly hear manufacturers say that they take their customers' feedback and input seriously, but Patriot puts action to those words. The Viper V760, debuted last year with Kailh Brown mechanical keyswitches, but thanks solely to customer feedback, this year's Viper, the V770, has a different switch beneath its keycaps.

On the V770, Patriot dispenses with the Kailh Brown's tactile bump in favor linear Kailh Red switches. This is our first encounter with Chinese manufacturer Kaihula's switches in

this roundup, so if you're unfamiliar with them they have similar profile to Cherry's MX switches of the same color. Kailh and Cherry MX Red switches are both silent, provided you don't bottom them out. Kailh Reds are slightly stiffer, requiring 50cN to actuate. We won't go so far as to say the difference is imperceptible for everyone, but we thought the Viper V770 gave us performance consistent with other keyboards in the roundup that used Cherry's Reds. Instead of declaring one Red superior to the other, because you could easily disagree, we'll say this: The action on Patriot's keyboard was fast, responsive, and accurate. Gamers, get in line.

Patriot competes with Razer for the best wrist rest of the bunch (an overlooked aspect that we wish more companies would devote more attention to), but for different reasons. The BlackWidow Chroma V2's wrist rest is a Tempur-Pedic California King bed you buy for your wrists, the Viper V770's is a Vegas vacation (not that the latter is uncomfortable, per se, thanks to a soft-touch coating). When you magnetically attach the V770's wrist rest to

the keyboard, it illuminates a brilliant strip of LEDs. An aluminum backplate gives the keyboard a sharp look and a stiff backbone.

Patriot's software completes the package. It lets you control and customize the Viper V770's RGB LEDs, as well as program macros. You can set up per-key lighting, choosing from 16.8 million colors, or punch in one of 10 effects, with some customization to boot. The Viper V770 has five dedicated macro keys, but you can record to every key on the board if you like (with the exception of the Windows key).

We liked Patriot's Viper V760 last year, and we like the Viper V770 this year. Anyone who wants quick keys, great LED lights, and a solid configuration utility, all wrapped in a stylish chassis, needs this keyboard on their short list.

Razer BlackWidow Chroma V2

It's hard to believe that Razer is almost a teenager. Where other PC companies eventually recognized the tremendous purchasing power gamers possessed (not to mention their influence over friends and family), Razer has had an unswerving focus on gamers since its inception. As a

result, the company has produced some truly iconic hardware. A good example is its BlackWidow keyboards, which have gone through a number of revisions over the years. The latest is the Chroma V2.

BlackWidow keyboards used to use Cherry MX switches, but now they have Razer's own—sort of—mechanical switches. Manufacturing partnerships with Kaihua (which makes Kailh switches) and Greetech have given us Razer Green (tactile and clicky), Orange (tactile and silent), and Yellow (linear and silent) switches. Requiring 50cN, 45cN, and 45cN, respectively, to actuate, Razer lines up its switches against Cherry MX Blue, Brown, and Red switches. Our BlackWidow Chroma V2 had Yellow switches, which do indeed feel very similar to Cherry's Reds. They're smooth, fast, and responsive, all traits you want in a gaming keyboard. After using and enjoying them, we have no reservations about the Razer Yellows. We'll have to take Razer at its word that the switches are good for 80 million keystrokes, but the bottom line is that they're capable of going toe-to-toe with other high-end mechanical switches. There is a column of five dedicated macro keys on the left side of the board.

Razer has always prized design, and the BlackWidow Chroma V2 is no exception. We'd even call the keyboard's aesthetic understated. It's only visual flourish (aside from the RGB LEDs, obviously) is an LED-lit Razer logo on the front of the board. The LEDs themselves do have a nice glow that the matte black finish on the frame accentuates. The plastic frame does flex slightly under pressure, but the BlackWidow Chroma V2 nonetheless feels solid. The unheralded star, though is the included wrist rest. The plush padding makes it easily the most comfortable of the bunch, and perfect for nonstop gaming sessions (though it remains to be seen how the padding would wear over time). It also magnetically attaches to the keyboard. Razer has done beautiful, if simple, work here.

Although the build quality and per-formance of the keyboard itself is

BlackWidow Chroma V2
$169.99 | Razer | www.razerzone.com

HEAVY GEAR
4.0 OUT OF 5
CPU

Specs: Switch type: Mechanical (Razer Yellow); 80 million keystroke life span; Interface: USB; Macros: Yes (5 dedicated keys); Per-key RGB backlighting (16.8 million colors); 10-key rollover anti-ghosting; Warranty: 2 years

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

great, the market is brimming with cheaper options that have equally good mechanical switches and solid designs. So, what exactly does $170 buy you? The BlackWidow Chroma V2 is a great keyboard, but what puts it in the upper echelon of gaming keyboards is Razer's software package, which has been polished and refined over the years. Razer Synapse gave us extensive and intuitive control over the keyboard's macros and lighting effects. With Chroma, you can design your own effects or download community creations, including game-specific packages. These tools aren't simply well-developed extras; they're an integral part of Razer's flagship keyboard.

Usually, when hardware doesn't surprise us, it's a disappointment. With the BlackWidow Chroma V2, it would've been a bigger surprise if Razer hadn't reasserted its power. Sometimes, you have to pay for greatness.

Topre RealForce RGB

Despite their protestations to the contrary, power users are as susceptible to herd mentality as any other group. Ask a group of enthusiasts whether they prefer AMD or NVIDIA graphics cards, for example, and expect a rancorous partisan debate, with both sides passionately stating their case.

When it comes to keyboards, there is a very big herd that wants you to believe that Cherry MX switches are the mechanical keyswitches you want. The idea that you'd want a different mechanical keyswitch is nonsensical. The contention that a terrific keyswitch can have the properties of a rubber dome—heresy. Do you think Japanese company Topre concerns itself with the opinions of the herd?

If the RealForce RGB is any indication, it does not. Regularly billed as a hybrid, the switch Topre uses in this keyboard is what the company calls "electrocapacitive," which is short for "electrostatic capacitive." We detailed the RealForce RGB's unique switch last month (see page page 20 in the August 2017 issue), but here's a quick

RealForce RGB
$232 | Topre | www.topre.co.jp/en

Specs: Switch type: Hybrid (Topre electrocapacitive); 50 million keystroke life span; Interface: USB; Macros: Yes; Per-key RGB backlighting (16.8 million colors); full anti-ghosting; Full n-key rollover; Warranty: 1 year

recap: Rubber domes under each keycap compress, and the top of the dome makes contact with the PCB's circuit. A conical spring above each dome is largely responsible for the switches' unique feel, and Topre has other tricks, such as using O-rings to dampen the switches' acoustics.

Requiring 45cN to actuate, Topre's switches are comparable to Cherry MX Reds and Browns, and they do have a light touch. The RealForce RGB's keys felt a little crisper than the Cherries, and they're whisper-quiet if you can train your fingers to not bottom out the keys. That's easier said than done, though, and the RealForce RGB's Spacebar in particular has a distinct *clack* if you bottom it out, which happened frequently. That said, typing on the RealForce RGB felt outstanding. The action was smooth, and the tactile feedback from the switches felt outstanding to us. Topre's switches are more than capable of competing with the best in the business.

Elsewhere, the RealForce RGB distinguishes itself in a couple of ways. The keyboard's stems are compatible with Cherry MX keycaps, which gives you access to a substantial buffet of aftermarket keycaps. (Real mechanical keyboard aficionados go whole-hog on this type of customization, so MX keycap compatibility is a bigger feather in the RealForce RGB's cap than you might think.) From a functional standpoint, this keyboard's real knockout feature

is its Actuation Point Changer. Letting you adjust the switches' actuation point (1.5mm, 2.2mm, or 3mm), either globally or on a per-key basis, APC means the RealForce RGB can be a fast gaming keyboard or a typing tank for anyone with heavy fingers. The difference is subtle at first, but as you experience typing at different actuation points you'll understand how awesome this feature is.

Although the RGB lights on the keyboard have a nice shine, the customization options are a somewhat limited. First and foremost, the RealForce RGB is a board for people who are fanatics about the overall typing experience. The $232 price tag is a chunk of change (however, Topre has discounted it to $199.99 until the end of September), but if you fall in love with the switches this will be the last keyboard you'll ever need.

Get On Board

If there's one thing that unifies these keyboards, it's that they're all unequivocally superior to that bottom-of-the-barrel keyboard you've been suffering with for years. Although we're trending toward a mandatory LED tax on gaming keyboards, with a little diligence you can still find exactly the mechanical keyboard you want for exactly the price you want to pay. We're confident that one of these boards will become your fingers' new best friend. ∎

BY VINCE COGLEY

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

GT75VR Titan-082
$4,299 (as tested)
MSI
us.msi.com

MSI GT75VR Titan

Enthusiasts who follow product announcements at big shows, such as CES and Computex, know some of the biggest headliners never make it to consumers. Some components are prototypes, while other items turn out to be infeasible for mass production. MSI's GT75VR Titan was one of the "hot" products of this year's Computex, and fortunately for enthusiasts, MSI has followed through with the hyped DTR (desktop replacement notebook). Our $4,299 sample boasts Intel's Core i7-7820HK, 64GB of DDR4-2400, and NVIDIA's GeForce GTX 1080. There are also two Samsung PM961 drives to form a RAID 0 configuration using PCIe, NVMe SSDs.

As with any DTR, the GT75VR Titan is only somewhat portable—it weighs in at 9.92 pounds. And when it comes to bulk, the 17.3-inch screen and powerful cooling system doesn't do the notebook format any favors. Enthusiasts familiar with DTR understand that you won't be hauling this notebook around all day long, but it's possible to use on the go, should you need it.

With these disclaimers out of the way, power users can't ask for much more from a notebook. The Intel Core i7-7820HK, for example, is a quad-core mobile CPU with Hyper-Threading to process up to eight concurrent threads. With a base speed of 2.9GHz and a healthy Turbo Boost of 3.9GHz, the Core i7-7920HK is one of the fastest mobile processors available. Multitasking and video rendering duties are further enhanced by this notebook's 64GB of DDR4-2400 memory.

MSI offers a version of the GT75VR Titan with two GeForce GTX 1070 GPUs in SLI, but this configuration's GeForce GTX 1080 is capable of gaming at the notebook's native 3,820 x 2,160 resolution without the need for a second card. In our game testing, the notebook delivered 53fps in Metro: Last Light and 45fps in Witcher 3 at the 4K resolution and highest settings. Games looked great on the IPS panel. The autumn scenes in Witcher 3, in our testing, were particularly vibrant.

The GT75VR Titan's standard storage subsystem is another area where MSI goes above and beyond. With almost a 1TB (952GB effective) of storage from the Samsung PM961 drives, you won't be lacking for storage space on the OS drive. CrystalDiskMark tests on the RAID 0 configuration showcased a Sequential Read Speed of 3295MBps and Sequential Write of 2961MBps. Another 1TB (908GB effective) of capacity is available via the Hitachi Travelstar HDD.

MSI complements the top-of-the-line hardware with extras that gamers and enthusiasts will appreciate. Let's start with the SteelSeries Rapid Mechanical RGB keys, which have action that feels and sounds like Cherry MX Blue switches. The onboard SteelSeries Engine 3 also allows for per-key RGB lighting control.

Continuing with game enhancing features, the GT75VR boasts an ESS SABRE DAC that supports up to 32-bit/384KHz audio and what MSI calls "high-res" audio. Essentially, the enhanced audio allows for more accurate playback of lossless audio and other digital music recorded at a high sample frequency. MSI partners with Nahimic for sound processing, and the preinstalled

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

Benchmark Results	MSI GT75VR Titan
3DMark Fire Strike	14816
Graphics Score	18929
Physics Score	11173
PCMark 10	5531
Essentials	7770
Productivity	7592
Digital Content Creation	6971
SiSoftware Sandra 2017	
Dhrystone AVX2 (GIPS)	161.71
Whetstone AVX (GFLOPS)	95
Multi-Media Integer AVX2 x32 (Mpixels/s)	458.21
Multi-Media Long-int AVX2 x16 (Mpixels/s)	166.3
Multi-Media Quad ALU x1 (Mpixels/s)	1.83
Floating B/F AVX/128 (GBps, mem bandwidth)	29.14
CrystalDiskMark 5.1.2 (MBps)	
Sequential Read (Q32T1)	3295
Sequential Write (Q32T1)	2961
Random 4K Read (Q32T1)	640.6
Random 4K Write (Q32T1)	567.3
POV-Ray 3.7 (Pixels/s)	1634.13
Cinebench 15 (Points)	760
Games	(3,820 x 2,160)
Metro: Last Light (Very High, 16xAF; SSAA off)	53fps
Sniper Elite 4 (VSync off, Ultra, DX12)	62fps
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	45fps

Nahimic 2 utility features a 3D sound feature for virtual 7.1 surround sound. You can combine the virtual surround sound with Nahimic's Sound Tracker tool for onscreen indicator of where in-game sounds originate.

Network connectivity, both wired and wireless, is on the bleeding-edge. The Ethernet connection is powered by Killer MULTI GIG and supports wired speeds up to 10Gbps. Although most ISPs don't yet provide enough bandwidth for this speed, the MULTI GIG port does mean the notebook will be ready for when next-gen broadband arrives in your neighborhood. The Wi-Fi connection is also a Killer product, the Wireless AC-1535 that supports MU-MIMO and beamforming.

We've already covered a bit of the GT75VR Titan's performance in our game and storage tests, but there are other results worthwhile to explore.

In Cinebench 15, for example, the notebook generated 760 points in the CPU test—a good mark for a mobile processor. The dual-channel DDR4-2400 memory was also speedy, delivering 29.14GBps in SiSoftware Sandra's Memory Bandwidth test. In the new PCMark 10 benchmark, the GT75VR Titan produced an overall score of 5331, highlighted by a Digital Content Creation mark of 6971.

MSI continues to improve upon its Titan notebooks, and the changes are much more than keeping up with modern CPU and GPU architecture. Cutting-edge additions, such as mechanical RGB keys, support for high fidelity audio, and Killer networking, improve the all-around experience. The GT75VR Titan's all-around luxury is in line with the $4,299 cost. ∎

BY NATHAN LAKE

Specs: CPU: Intel Core i7-7820HK; Memory: 64GB DDR4-2400; Chipset: Intel CM238; GPU: NVIDIA GeForce GTX 1080; Storage: 2 x Samsung 512GB PM961 (RAID 0), 1TB Hitachi Travelstar; Networking: Killer MULTI GIG 10Gb, Killer N1535; OS: Windows 10 Professional; Ports: 5 x USB 3.0, 1 x USB Thunderbolt 3 (Type-C), 1 x HDMI 1.4, 1 x mini DP 1.2, 1 x S/PDIF, audio I/O; 3-in-1 card reader (SD/SDHC/SDXC); Warranty: 1 year

CPU RANKING 0 = ABSOLUTELY WORTHLESS 2.5 = ABSOLUTELY AVERAGE 5 = ABSOLUTELY PERFECT

Core i7-7820X
$589
Intel
www.intel.com

Intel Core i7-7820X

We still don't know how Intel's highest core-count Skylake-X processors will perform, but here's an eight-core appetizer to nibble on in the meantime.

The Intel Core i7-7820X is, at least architecturally, closer to the Core i9-7900X than to the Kaby Lake-X Core i7-7740X, and that's a good thing. This processor features eight cores with Hyper-Threading enabled, letting it handle up to sixteen concurrent threads at once. The base clock is set to a modest 3.6GHz, but it has a Turbo Boost 2.0 frequency of up to 4.3GHz. Those clocks put it at a rather significant single-core disadvantage compared to the fastest Kaby Lake-X processor, however, this processor is the least expensive of the X Series processors to have Intel Turbo Boost Max Technology 3.0 switched on, which gives the fastest core a little more room to run, to the tune of 4.5GHz, which is the Core i7-7740X's Max Turbo frequency.

But there are other things about the Core i7-7820X that make it a significantly better choice for enthusiasts, such as its beefier 11MB L3 cache and an onboard quad-channel memory controller, which does wonders for memory-limited applications and actually lets you use all of the memory slots on your X299 motherboard. Another thing that gamers and storage savants will be happy to hear is that this processor supports up to 28 PCIe 3.0 lanes, which is 12 more than the Core i7-7740X and anything currently available on Intel's mainstream Z270 platform.

Other features include an 8GTps DMI 3.0 bus and support for up to 128GB of DDR4-2666, which is a bit faster than the DDR4-2400 speed limit that the 6-core 12-thread Core i7-7800X is saddled with. The 7820X features a few tweaks compared to original Skylake procs, including a rebalanced cache hierarchy that dedicates more private MLC (Mid-Level Cache) to each of the chip's 8 cores, resulting in modest improvements in IPC (instructions per clock), but at the cost of some increased latency. Other extras include AVX-512 instructions, support for Intel SpeedShift technology that enables the processor to change P states in as little as 1ms, an improved the front-end, deeper out-of-order buffers, an increased the execution unit count, and higher load/store bandwidth.

This processor is manufactured on Intel's 14nm process-based die and it comes with a rather high 140-watt TDP. When we overclocked the CPU, we got stable scores at 4.3GHz, with a minimal bump in voltage. These chips get hot fast, so we didn't get pushy.

The Intel Core i7-7820X is a solid, if slightly expensive, starting point for enthusiasts looking to build an X299-based system that needs tons of memory bandwidth and could do with a decent amount of PCIe lanes. ∎

BY ANDREW LEIBMAN

	Intel Core i7-7820X	i7-7820X OCed @ 4.3GHz
3DMark Fire Strike Ext.	13,601	13,615
Graphics Score	14,400	14,314
Physics Score	20,963	22,230
Graphics Test 1	76.8fps	76.40fps
Graphics Test 2	52.84fps	52.51fps
Physics Test	66.55fps	70.57fps
Combined Test	32.57fps	32.53fps
PCMark 10 Score	6,400	6,782
Sandra 2017 Platinum		
Dhrystone Integer Native AVX2 (GIPS)	363.68	393
Whetstone Single-float Native AVX (GFLOPS)	216.7	233.16
x128 Multi-Media Integer AVX512/BW (Gpixels/sec.)	1.27	1.51
x64 Multi-Media Long-int AVX512/DQW (Mpixels/sec.)	426.69	499.29
x1 Multi-Media Quad ALU (Gpixels/sec.)	4.07	4.59
x64 Multi-Media Single-float AVX512F (Gpixels/sec.)	1.49	1.83
Integer Memory Bandwidth B/F AVX512/512 (GBps)	49.47	47.4
Floating Memory Bandwidth B/F AVX512/512 (GBps)	50.85	48.89
Cinebench 15 (Points)	1,739	1,850
POV-Ray 3.7 (Pixels/sec.)	3,696.44	3,983.04
Sniper Elite 4 (Vsync Off, Ultra, DX12)	120.29fps	120.97fps
The Witcher 3 (Vsync off, Unl.fps, Ultra)	104.75fps	110.03fps

Specs: Clock speed: 3.6GHz base, 4.5GHz Turbo Boost Max Technology 3.0; 8-cores; unlocked multiplier; quad-channel DDR4-2666 memory; 28 PCIe lanes; 11MB L3 Cache; Hyper-Threading; Turbo Boost; 14nm; 140W TDP

Test System Specs: Motherboard: ASRock X299 Taichi; GPU: EVGA GeForce GTX 1080 Ti FTW3; Memory: 32GB Kingston HyperX DDR4-3200; Storage: 480GB Patriot Hellfire PCIe SSD; OS: Windows 10 Enterprise

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

HEAVY GEAR
3.0 OUT OF 5
CPU
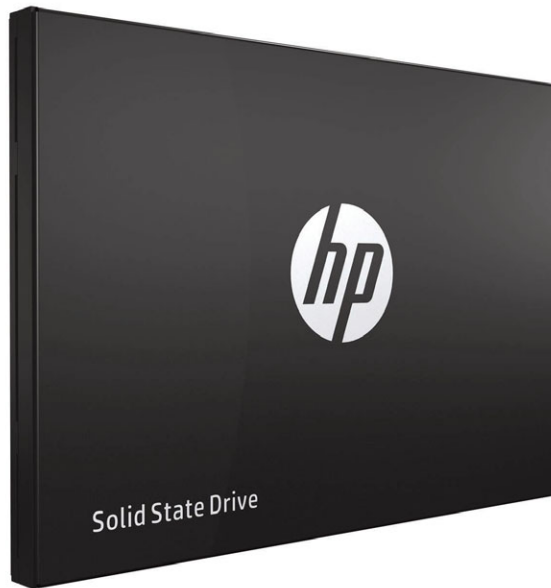
SSD S700 500GB
$199.99 | HP | www.hp.com

Benchmark Results	HP SSD S700 500GB
CrystalDiskMark 5.2.1*	
Sequential read	521.7
Sequential write	464.5
4K read	25.50
4K write	115.2
Sequential read (QD32)	557.5
Sequential write (QD32)	512.5
4K read (QD32)	222.3
4K write (QD32)	322
PCMark 8 Storage	**4904**
AS-SSD 1.9*	
Sequential read	524.16
Sequential write	461.46
4K read	19.40
4K write	100.96
4K read (64Thrd)	204.29
4K write (64Thrd)	293.58
*all results in MBps	

HP SSD S700 500GB

Ask anyone in the enthusiast old guard about Hewlett-Packard, and you'll probably get a condensed dissertation about the company's pivotal role in not only establishing personal computers but also Silicon Valley itself. Ask a LAN party youngling playing Rocket League on his dad's gaming rig, and the answer will probably be, "I think they made my grandparents' printer."

Indeed, although HP is a dominant force in a lot of tech industries and still maintains a very healthy share of the overall PC market, the company has been searching for an identity that resonates among gamers and other power users. This summer, HP seems to be finding its way, announcing the OMEN line of gaming systems and becoming an official partner of the 2017 Overwatch World Cup. Almost simultaneously, HP is attempting to make inroads in another enthusiast arena: solid-state drives. The SSD S700 and SSD S700 Pro series make up the initial foray. HP sent us its biggest S700, a 500GB 6Gbps SATA drive that slips in just under the $200 mark. The math practically does itself. Based on this drive's MSRP, you're paying $0.40/GB.

Let's get this out of the way now: These SSDs aren't going to burn up the test track, which is largely a result of 6Gbps SATA bus bottlenecking throughput. Instead, HP is positioning the S700 and S700 Pro as sources of affordable, long-lasting solid-state storage. Equipped with a Silicon Motion controller and a stack of 3D TLC NAND, the SSD has the hallmarks of an approachable, cost-effective drive.

HP has imbued the S700 with a handful of other benefits intended to help it stand up to regular punishment. There's advanced wear-leveling, which we've come to expect at this point, so this SSD should be good for 295 TBW. Higher Order LDPC (low-density parity check) Error Correction keeps data on the drive safer. An all-metal enclosure acts as a natural heatsink; combined with the S700's 7mm thickness, it's a good fit for laptops in need of a better boot drive. Laptop users should also like that the S700 uses a scant 5mW in sleep mode.

We pitted the 500GB S700 against CrystalDiskMark and AS-SSD, and it delivered precisely the throughput that's consistent with modern 6Gbps SATA SSDs. The S700 might not be your next boot drive, but it's a perfectly acceptable source of fast, dependable supplemental storage or a can't-miss upgrade for a sluggish laptop. ■

BY VINCE COGLEY

Specs: Interface: 6Gbps SATA; Controller: Silicon Motion SM2258; Maximum sequential read/write: 560MBps/515MBps; Random 4KB read/write: 75,000 IOPS/95,000 IOPS; Form factor: 2.5-inch; Warranty: 3 years
Test system specs: Processor: Intel Core i9-7900X; Motherboard: ASROCK X299 Taichi; GPU: EVGA GeForce GTX 1080 Ti FTW3; Memory: 32GB Corsair Vengeance LED DDR4-3200; Storage: 480GB Patriot Hellfire; OS: Windows 10 Enterprise

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

HEAVY GEAR
4.0 OUT OF 5
CPU

Eisbaer 420 CPU
$152.30
Alphacool
www.alphacool.com

Alphacool Eisbaer 420 CPU

At the beginning of the year, we reviewed Alphacool's Eisbaer 360, an all-in-one CPU cooler with quick release fittings to let you expand the loop without needing to drain the system or take the AIO apart. Alphacool recently added a new flagship CPU cooler, the Eisbaer 420, that brings a similar feature set with a 420mm copper radiator and three 140mm Eiswind 14 fans. If you have the space for such a voluminous radiator inside your case, this expandable AIO might just be for you.

The Eisbaer 420 CPU, similar to the Eisbaer 360 CPU, comes completely preassembled and factory-filled with coolant, so you can install it right away. Alphacool includes mounting kits for all modern Intel processors, including LGA 2066 sockets. On the AMD side, there are mounting kits for AM4 and previous generation AMD processors. Alphacool tells us a TM4 bracket for Threadripper chips is now available for preorder and should be available by the time you read this. Maybe more importantly, the Eisbaer AIO's cold plate is large enough to cover the Threadripper die.

We've been big fans of Alphacool's integrated quick disconnect system, and the same fittings are present on the Eisbaer 420 CPU. Notably, Alphacool also sells Eiswolf GPX-Pro AIO kits (GPU coolers) with the same quick disconnect system. Should you have a different GPU block in mind, Alphacool also sells adapters to make the quick disconnect system work with standard G1/4 fittings. We also like that Alphacool includes a fill port on the pump/water block unit, so you can quickly add coolant if you do opt to expand the loop.

Alphacool tells us that the Eisbaer 420 CPU is the largest AIO available, and after a bit of research, we found no other closed-loop kits with a 420mm radiator. The extra-long and wide copper fin structure, of course, is great for heat dissipation, but support for this big bear of a radiator requires a huge case. Even some full towers might not have room for it. We installed the AIO into the top panel of a Thermaltake Urban T81, where it fit quite nicely.

The three Eiswind 14 fans included with the Eisbaer 420 CPU are different than the PWM-controlled Eiswind 12 fans that come with the Eisbaer 360 CPU. Despite sharing the same series name, the 140mm Eiswind 14 fans feature a static 1,100rpm fan speed. The tremendous length of the radiator, in part, alleviates the need for super-speedy fans, but we still like having PWM control as an option for keeping noise to an absolute minimum when the PC is idle.

Much like the Eisbaer 360 CPU, the 420 model offers quite a bit of headroom for overclocking. We tested the unit with Intel's Core i7-7820X and ASRock's X299 Taichi. Prime95's SmallFFT torture test pushed average CPU temperatures to only 55.63 degrees Celsius with a maximum of 60 C. We also ran POV-Ray 3.7 for ten minutes, where CPU temperatures averaged 52.7 C with a max of 58 C. In idle, the Core i7-7820X averaged a cool 25 C.

Alphacool's expandable AIO design is especially powerful when paired with large radiators, such as what you'll find on the Eisbaer 420 CPU, as the unit has greater cooling potential for loop upgrades down the road. Compatibility will likely be a roadblock for some users, but otherwise, there's little to complain about in terms of design, performance, and pricing. ■

BY NATHAN LAKE

Specs: Materials: copper (waterblock and radiator); Socket compatibility: Intel LGA 2066/2011(3)/2011/1366/115X/771/604, AMD FM2(+)/FM1/AM3(+)/AM2(+)/939/940/G34; Pump: 2,600rpm, 7-13.5V; Fans: 3 140mm Alphacool Eiswind 14 fans (1,100 rpm); Radiator dimensions: 1.18 x 5.66 x 19.26 inches (HxWxL); Warranty: 2 years

Test System Specs: Processor: Intel Core i7-7820X; Motherboard: ASRock X299 Taichi; GPU: EVGA GeForce GTX 1080 Ti FTW3; Memory: HyperX 32GB Predator DDR4-3000; Storage: 480GB Patriot Hellfire; OS: Windows 10 Enterprise

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

HEAVY GEAR
4.0 OUT OF 5
CPU

VOID PRO Surround
$79.99
Corsair
www.corsair.com

Corsair VOID PRO Surround

Corsair recently launched its new VOID PRO family of gaming headsets, and we opted to take the VOID PRO Surround for a test drive. Compared to other headsets in the new product line, the VOID PRO Surround resides in a more affordable neighborhood, but you aren't missing out on audio quality when you opt to pick up this model over one of the others.

The difference between the unit we tested and the VOID PRO RGB Wireless is all in its name; the $99 cordless unit features a built-in battery (over 16 hours of battery life, 2.4GHz wireless audio with up to 40ft of range) and an RGB LED under the Corsair logo on the cans. There's a $129 yellow VOID PRO RGB Wireless SE (Special Edition) that comes with everything mentioned above and a bundled receiver dock and wireless USB adapter holder. There's also a basic VOID PRO RGB that carries the same $79 price as the VOID PRO Surround, but it comes with a corded USB-only interface.

With the VOID PRO Surround, we like having the option of plugging in the USB dongle to take advantage of the headset's Dolby Headphone 7.1 surround sound capabilities, or putting it away when we want to switch to a non-PC source, such as a game console or smartphone. We do miss out on the RGB

LED-backlit logo the other VOID PRO models feature.

No matter which unit you choose, however, they all come equipped with custom tuned 50mm Neodymium drivers, which deliver a rich and full sound experience whether you're enjoying surround or stereo content. The unidirectional noise-cancelling microphone on this unit delivers a similar high-quality experience, with its 50Hz to 18kHz frequency response and -38dB (+/-3dB) sensitivity.

In addition to improving the experience for your teammates, the VOID PRO Surround also supports Sidetone Control, which lets you hear your voice through the headphones to keep you from shouting unnecessarily or becoming the "heavy breather" of the group. Better yet, the VOID PRO Surround has been DISCORD Certified, which means it'll play nice and sound great when you're running one of the most popular gaming chat apps.

The mic and sound performance of a headset is important, sure, but it's really only half of the story. We're happy to report that Corsair have nailed the comfort aspect as well; the VOID PRO Surround is one of the most comfortable headsets we've used. It weighs a hefty 13.4-ounces, but Corsair's engineers have figured out a way to evenly distribute

that weight across the microfiber mesh headband and memory foam ear cup cushions. Those cushions are also large enough that they're not resting on any sensitive portions of your ears. As a result, the headset stays put and feels great, even after hours of nonstop gaming.

We downloaded Corsair's CUE Control utility to enable/disable the Dolby Headphone 7.1 surround sound, but there's no RGB LED and currently no other Corsair components installed on our test system, making the software seem largely unnecessary beyond offering a handful of EQ settings, which we rarely adjust anyway.

The VOID PRO Surround comes with your choice of Cherry Red or Carbon (black) can highlights. The unit is composed of a plastic adjustable headband, with anodized black aluminum brackets between the headband and the cans, letting them swivel and rotate for a perfect fit or easy travel.

After several days spent with the VOID PRO Surround effectively glued to our scalp, we're pleased to report that this unit is comfortable and great-sounding enough that we'd be content to use it for gaming, music, streaming video, movies and more, all day, every day. ∎

BY ANDREW LEIBMAN

Specs: Drivers: 50mm neodymium driver, 20Hz to 20kHz; Impedance: 32 ohm @ 1kHz; Mic: 50Hz to 18kHz; Sensitivity: -38dB (+/-3dB); Controller: On-can volume; LEDs: None; Connector: 3.5mm plug, USB dongle for Dolby Headphone 7.1

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

ARCTIC BioniX F120 & F140

BioniX F120 & F140
$14.99/F120, $15.99/F140 | ARCTIC | www.arctic.ac

The majority of case fans come with a two-year warranty, and some higher-end models are backed by a five-year warranty. ARCTIC's new BioniX F120 (a 120mm fan) and F140 (a 140mm fan) series boast a nearly unheard of 10-year warranty. Why is ARCTIC so confident in the BioniX fans, you might ask? The company indicates that most fans are designed with a 1- or 2-phase motor, while the BioniX fans feature a 3-phase motor that, by comparison, drastically reduces motor temperature. Turning down coil heat, according to ARCTIC, quadruples the life span of the fan motor and also reduces noise. Power users should also like that the BioniX fans produce high airflow and feature a wide PWM range (200-1,800rpm).

On the BioniX line, ARCTIC eschews the bright white blades so commonly found on its low-noise "F" series for black blades and a colored inner frame. Our BioniX F120 sample features a white inner frame, while the BioniX F140 boasts a red inner frame. ARCTIC also offers the BioniX line in green and yellow colors. By moving the accent color to the frame, rather than the rotating blades that blur during operation, the color is more distinct inside the case.

In addition to changing up the look, the BioniX fans bring some serious airflow to ARCTIC's fan lineup. The BioniX F120 is rated for 69cfm at the full 1,800rpm, while the F140 hits 104cfm at full throttle. Impressively, the rated airflow matches some fans that we've recently tested that operate at 2,000rpm. ARCTIC's engineers tweaked the fan blade design to generate higher airflow without increasing noise.

At full speed, we'd rate the fan noise as average for both the 120mm and 140mm models. The fans aren't silent when the PC is under full load, nor are they so loud as to be distracting. The BioniX's 200rpm minimum fan speed, on the flip side, ensures the F120 and F140 fans are quiet during idle. In our testing, noise levels aren't really noticeably until the fan reaches 1,200rpm, so the BioniX fans are unobtrusive in everyday application.

ARCTIC makes a small, but important, addition to the PWM plug by including both a male and female connector. The design makes it easy to set up multiple BioniX fans in a series. The BioniX series also supports ARCTIC's PWM Sharing Technology, where up to 10 fans (assuming the motherboard has a high power fan header) can run in a daisy-chain for a single point of PWM control. The fan's female 4-pin header, of course, could also support any other 3- or 4-pin fan—not just ARCTIC's BioniX line.

The BioniX F120 and F140 are well-designed fans, and in particular, we like the wide PWM range and impressive airflow at 1,800rpm. The 10-year warranty and dual PWM plug set add to the premium features. With fans on the leading edge of the RGB LED craze, it's notable that ARCTIC foregoes LEDs entirely on these "gaming" fans, but the fan's look is still bold enough to attract attention inside a case. ARCTIC tell us that the fans should be available by September 13th. ∎

BY NATHAN LAKE

Specs: Dimensions: 120 x 120 x 27mm (F120), 140 x 140 x 28 (F140); Speed: 200-1,800rpm; Maximum airflow: 69cfm (F120), 104cfm (F140); Maximum noise: 0.5 Sone (F120, 0.6 Sone (F140); Connectors: 4-pin PWM (male and female); LED: none; Current: 0.2A (F120), 0.25 (F140); Warranty: 10 years

CPU RANKING   0 = ABSOLUTELY WORTHLESS   2.5 = ABSOLUTELY AVERAGE   5 = ABSOLUTELY PERFECT

State-Of-The-Art Standards

AMD XFR

Last month we looked at Intel's Turbo Boost Technology as it has evolved over the past eight years, and now it's time to shine the spotlight on AMD's automated clock speed-tweaking technologies. Unlike Intel's technology, AMD has gone through a couple revisions, initially Turbo Core, followed by Turbo Core 2, which was ultimately scrapped in favor of Precision Boost and XFR (Extended Frequency Range) in the firm's latest Zen-based processors. But before we get ahead of ourselves, let's take a closer look at how AMD found itself with a series of processors that could do better than their base clocks on a consistent basis.

The Original Turbo

The idea of dynamic frequency scaling has its origins in technologies that significantly predate both Intel's Turbo Boost and AMD's similar efforts. The Turbo Button was a physical button that existed on the front panel of a handful of beige-box IBM compatibles that were shipped with processors that ran at faster core clocks than the original 4.77MHz of the Intel 8088.

Today, we take it for granted that upgrading our processor to a model that runs at a higher frequency always results in universal software compatibility and generally better performance across the board. But in the mid-to-late '80s, this was not the case. The developers of some early PC games used the CPU clock for timing animations (we're using the term "animations" loosely here) and in-game events, which meant that they only ran correctly if the processor was running at the CPU speed that the game was designed to use. PCs equipped with a Turbo Button

In the bad old days, some IBM compatibles needed to underclock the CPU via a Turbo Button just to play a handful of legacy games.
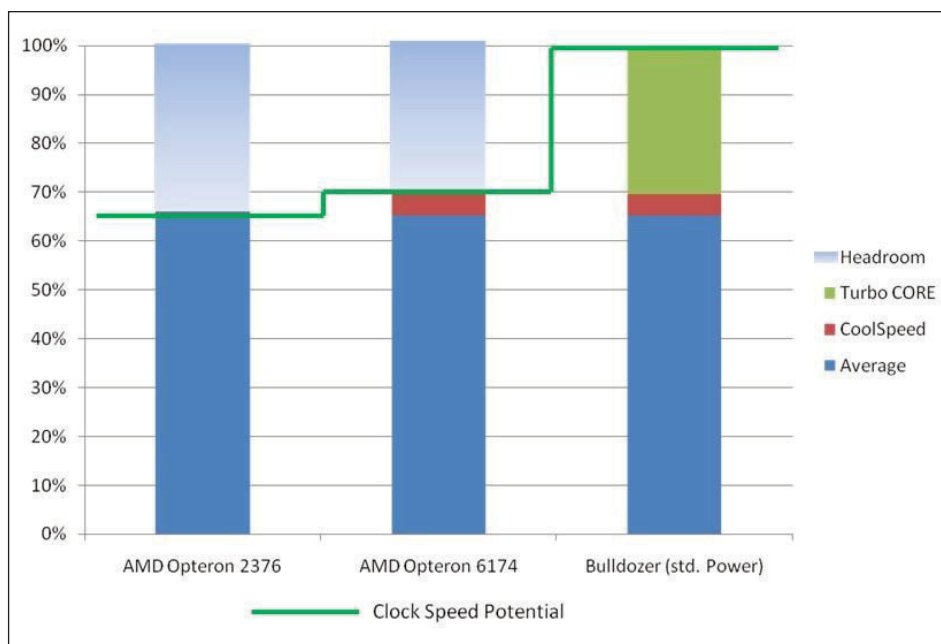
AMD's Bulldozer architecture may have a bad reputation among enthusiasts, but Turbo Core Technology gave you more bang for your buck.

It was as true then as it is now; High-end processors that consume significantly more than 140 watts have a hard time dissipating heat quickly enough using conventional (read: affordable) cooling devices to be commercially viable. Even stricter power and thermal limits, in the neighborhood of 65 watts, needed to be instituted on desktop processors that commonly shipped with low-profile, air-cooled CPU heatsinks. Mobile processors, which are heat- and power-limited to the tune of around 35 watts, can't simply run at higher generation-on-generation clocks to outperform their predecessors.

This has resulted in processors that, for the better part of the last decade, have had to make tradeoffs between core count and clock speed to stay within roughly the same thermal envelope. To simplify what we're talking about, consider that a single-core processor can stay within its power and heat output limits with a 4.2GHz core clock, but a dual-core processor will need to be clocked at 3.6GHz to do the same,

could effectively reduce the clock speed to support these software titles, and then run with Turbo enabled, or effectively full speed, for any software that didn't suffer this fault. Modern versions of turbo have flipped the script significantly, and we're grateful that these sorts of workarounds are no longer necessary.

The Heat & Power Problem

In last month's look at Intel's Turbo Boost technology, we implied that there was a link between multicore processors struggling with single-threaded software and Intel's desire to convert the power those idle cores weren't using into a real performance advantage. But even before anyone was making multicore processors, back in the days of NetBurst Pentium 4s and K7-based Athlons,

there was another problem that both Intel and AMD's chip designers were beginning to encounter, and that was their processors' physical limitations with regard to heat and power.

Turbo Core relied on P-state transitions to signal the system when to raise the base clock.

and a quad-core processor will take another 400MHz to 600MHz hit to its clock speed to operate within the same boundaries.

TDP VS. Power Draw

The terms TDP (Thermal Design Power, or thermal watts) and power draw (electrical watts) are often mistakenly used interchangeably. TDP refers to the measurement of the processor's thermal output and is designed to be used as a reference point for choosing a suitable CPU cooler. The TDP is a number that the processor should not consistently be approaching under typical loads, and if the TDP is met, thermal throttling will occur, resulting in significant drops in clock speed and performance. The TDP for any ASIC can be determined by subtracting the maximum temperature for the heat spreader junction (tCaseC) from the maximum temperature at the HSF fan inlet (tAmbientC), divided by the minimum degrees Celsius per watt rating of a heatsink.

If we take a look at the AMD Ryzen 3 1300X we reviewed recently, we can calculate its TDP by subtracting 71.3 (max temp at the processor's heat spreader) from 42 (max temp at heatsink), and then dividing the result by 0.451, which is effectively a minimum degrees-Celsius-per-watt capacity for the thermal performance of AMD-compatible coolers. This gives us a TDP of 64.96, or 65 watts.

Keep in mind that when we use a phrase like "maximum temperature," we're really referring to the highest operating temperature before the CPU begins to throttle its speed to prevent damage to the hardware. This is the upper limit of desirable performance, even when overclocking is factored in. The reference power draw limit (current times voltage) for AMD's Socket AM4 is 128 watts, and the processor's tendency to approach this number isn't influenced by aftermarket CPU coolers or other hardware choices.

When talking about Ryzen processors and A-Series APUs that plug into the AM4 socket, that 128 watts can be considered a constant. Note that the AMD Ryzen Threadripper's TM4 socket on X399 motherboards will have a significantly higher reference power draw

limit, considering the flagship AMD Ryzen Threadripper 1950X processor has a TDP of 180 watts. The AMD Wraith Stealth cooler, which ships with a number of the most affordable Ryzen 5 and 3 processors, conforms to the 0.451 minimum degrees-Celsius-per-watt rating mentioned above.

The Bulldozer Phenomenon

AMD's first implementation of dynamic frequency scaling for the purposes of improving performance occurred with the relatively recent Bulldozer architecture, which initially launched in early 2010 on the company's Phenom II processors, starting with the six-core Phenom II X6 1090T and 1055T, and later in 2011 in select AMD Opteron processors.

The technology, called AMD Turbo Core, was designed to bridge the gap between TDP and average power consumption, which is the amount of power that a processor is most likely to draw under load when running typical workloads. As it turns out, this gap can be rather massive.

According to a blog post from John Fruehe, former director of product marketing at AMD, the base clock speed on these processors was effectively a "worst-case scenario," assuming baseline cooling and workloads that draw atypical amounts of power. AMD determined the clock speed of these Bulldozer processors "using a methodology that includes using programs designed to stress every transistor at the same
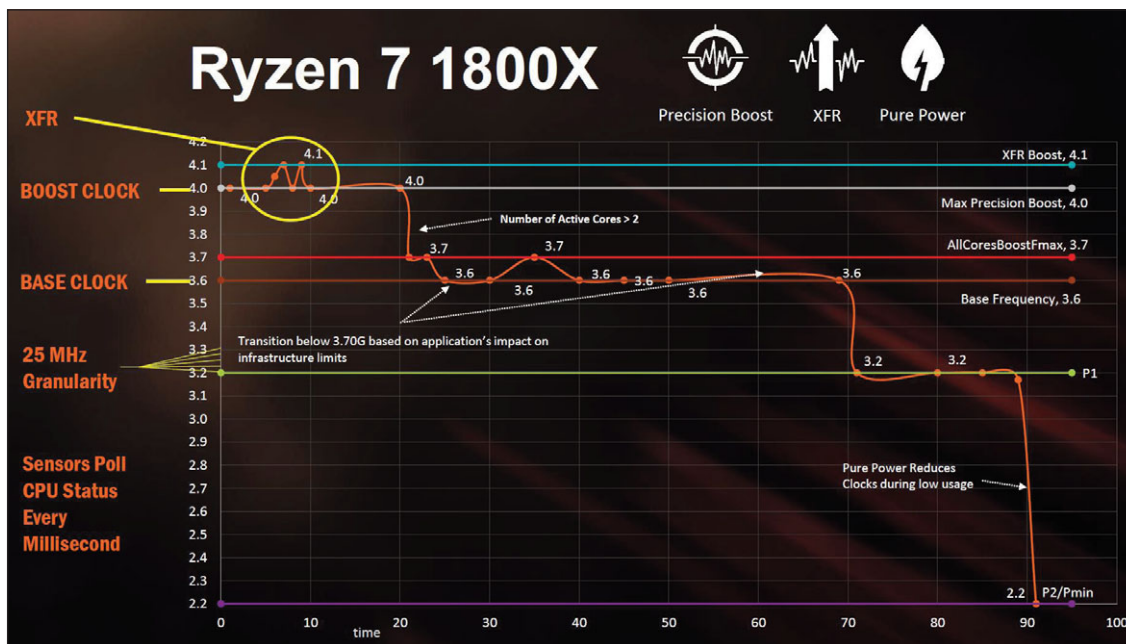
This chart from AMD shows how Precision Boost, XFR, and Pure Power work together to affect the clock speed of the flagship Ryzen 7 1800X.

Rewarding Enthusiast Cooling

- ▲ Permits frequencies above and beyond ordinary Precision Boost limits

- ▲ Clockspeed scales with cooling solution: air, water, and LN_2

- ▲ Fully automated; no user intervention required

Chart for illustrative purposes only

Precision Boost Max

Frequency

TIME

XFR is a tangible benefit for those who have opted to run a CPU cooler that can dissipate a significant amount of heat in a short amount of time.

time, maximizing the power consumption to try to reach TDP." In real-world scenarios, a processor will rarely be working very hard when running at its base clock, making this number a rather conservative estimate of the processor's real horsepower.

Another factor that can impact the clock speed of a given processor is the expected workload. AMD's Opterons can reasonably be expected to run server workloads, scientific simulations, and other highly threaded workloads, which means these processors will be running against their limits significantly more often than the typical consumer processor, which may spend 70% of its uptime running a web browser and media playback software, and the rest of the time running games, content-creation apps, encoding utilities, and other demanding CPU-limited applications. This is a big part of why Opteron and EPYC processors tend to operate at lower base clocks compared to Phenom, FX-Series, Ryzen, and Threadripper processors.

Prior to the arrival of Turbo Core Technology, AMD customers often lamented that processors with 95W TDPs seldom consumed more than 50W. For a customer tasked with

provisioning for a data center, this disparity can result in a lot of wasted rack space. To address the issue, AMD came up with the ACP (Average CPU Power) rating for its server and workstation processors, which still assumes a 100% loading, but more accurately reflects the processor's real-world behavior. A major enabling technology here was AMD's CoolSpeed, which effectively let the processor throttle when nearing the TDP, a capability we take for granted on modern processors

from AMD and Intel. As a result, the processor base clock speeds could start out higher to improve the performance of those typical workloads. But this only gave AMD's early efforts a modest 5% clock improvement. There was still a big performance gap that was just lying there, untapped.

Put simply, AMD Turbo Core lets the processor raise its clock speed dynamically, based on software demand, to as close to the processor's TDP as possible without incurring

THE RYZEN "X" FACTOR

"X" means more performance

- o Higher Base Clocks
- o Higher Boost Clocks
- o Twice the XFR Boost Headroom

Combine with an X370 motherboard to deliver the maximum eXperience

	Base	BOOST	XFR
Ryzen 7 1800X			
Ryzen 7 1700X			
Ryzen 7 1700			

CLOCK FREQUENCY

This chart shows just how the top Three Ryzen 7 processors compare with regard to base clocks, Boost clocks, and XFR clocks.

the wrath of CPU throttling. As a result, the published base clock started looking more like a minimum, with the Turbo Core speed being the maximum, which let customers more accurately determine the performance they could expect from the processors they bought.

Better Clocks Through Machine Intelligence

Although AMD's Turbo Core Technology can still be found on select AMD A-Series processors, the Zen architecture's SenseMI (Sense Machine Intelligence) feature set has scrapped the Turbo Core marketing terminology in favor of a handful of new technologies. AMD recently described SenseMI as an umbrella of technologies that covers Pure Power, Precision Boost, Extended Frequency Range, Neural Net Prediction, and Smart Prefetch.

The latter two technologies don't have much bearing on the processor's dynamically shifting frequency ranges, so we won't discuss them here. Pure Power, Precision Boost, and XFR, on the other hand, let the processor adjust its performance and power attributes to meet the application demand at hand. In order to accomplish this feat, a smart grid of interconnected sensors within each Ryzen processor is constantly reporting power and temperature data within 1mA, 1mV, 1mW, and 1 degree Celsius, up to a thousand times per second.

Although that's an incredibly useful trick, AMD doesn't merely run an identical power profile for every Ryzen processor. Pure Power is capable of tailoring the power consumption behavior of each processor to the silicon's specific capabilities. If the so-called "silicon lottery" was previously a hit-or-miss phenomenon of little interest to non-overclockers, on Ryzen processors a winning chip will perform better even when not specifically overclocked, improving the computing experience of anyone who buys it.

Precision Boost functions similarly to Intel's Turbo Boost, by raising or lowering the processor's clock speed in response to demand and thermal headroom. AMD's scheme lets the processor adjust clock speeds in 25MHz increments to grant an extra bit of speed. In comparison to past dynamic clock speed adjustments, 25MHz is rather fine-grained; this lets a processor inch its way faster without dropping back so dramatically once the thermal or electrical limits are encroached upon.

Ryzen processors rely on Pure Power to look at the distance to thermal junction maximums to determine the cooling capacity of the cooling solution, then adjust the speed accordingly when possible to deliver up to between 50MHz and 200MHz of extra clock speed. XFR is available on all Ryzen processors, but you get a bigger boost on models with an X suffix. The trio of Ryzen Threadripper processors (1950X, 1920X, and 1900X) as well as the Ryzen 3 1300X, each get up to a 200MHz XFR boost, while the remaining Ryzen processors with the *X* suffix get up to a 100MHz boost. All non-*X* Ryzen processors get just a

50MHz maximum XFR boost under the right circumstances. In these scenarios, whether a user is cooling the chip with air, liquid, or LN2, the Precision Boost, XFR, and Pure Power technologies will work together to level off at whichever limit is reached first, 60 tCaseC or 128W of electrical power.

Better Smarts, More Speed

To sum up, with its Ryzen processors, AMD has effectively built the processor to run smarter to take advantage of the environmental variables that we have some control over, such as the cooling solution with regard to the TDP. As a result, the processor can manage to run faster even under conditions that you have little control over, such as demanding workloads, heavily threaded tasks, or even lightly threaded tasks. In the future, we look forward to seeing how AMD iterates on its SenseMI technology to leverage its current strengths and shore up any shortcomings that may crop up with the new architecture. ∎

Processor Model	Cores/Threads	Base Freq.	Boost Freq.	XFR / Peak Freq.
Ryzen Threadripper 1950X	16/32	3.6GHz	4.0GHz	+200MHz / 4.2GHz
Ryzen Threadripper 1920X	12/24	3.5GHz	4.0GHz	+200MHz / 4.2GHz
Ryzen Threadripper 1900X	8/16	3.8GHz	4.0GHz	+200MHz / 4.2GHz
Ryzen 7 1800X	8/16	3.6GHz	4.0GHz	+100MHz / 4.1GHz
Ryzen 7 1700X	8/16	3.4GHz	3.8GHz	+100MHz / 3.9GHz
Ryzen 7 1700	8/16	3.0GHz	3.7GHz	+50MHz / 3.75GHz
Ryzen 5 1600X	6/12	3.6GHz	4.0GHz	+100MHz / 4.1GHz
Ryzen 5 1600	6/12	3.2GHz	3.6GHz	+50MHz / 3.65MHz
Ryzen 5 1500X	4/8	3.5GHz	3.7GHz	+200MHz / 3.9GHz
Ryzen 5 1400	4/8	3.2GHz	3.4GHz	+50MHz / 3.45GHz
Ryzen 3 1300X	4/4	3.5GHz	3.7GHz	+200MHz / 3.9GHz
Ryzen 3 1200	4/4	3.1GHz	3.4GHz	+50MHz / 3.45GHz

XFR is available on all Ryzen processors, but some models benefit more than others. This chart illustrates the available options.

MRM™
MAD READER MOD

Rey's Speeder

This issue's "Mad Reader Mod" marks Brian "Boddaker" Carter's fifth appearance in *CPU*'s monthly best-mod feature, which eclipses the number of wins by every other modder except one (Bill "Mnpctech" Owen). Carter won the mod contest at the most recent PDXLAN event, PDXLAN 30, beating out the four other excellent mods that were chosen as the contest's top five finalists. (You can see the other finalists in our PDXLAN coverage in this issue!)

We should point out that Rey's Speeder is Carter's third MRM-winning mod with a science-fiction vehicle theme; his first win came with his Battlestar Galactica mod, and our December 2011 issue's Mad Reader Mod was Carter's TRON Lightcycle PC. This one, of course, is a replica of the speeder Rey uses to haul her salvaged tech to market on Jakku in the first act of "Star Wars: The Force Awakens." It's also largely built from 3D-printed parts.

"I've always been a Star Wars fan and love doing Star Wars-themed builds (I built a Minecraft-style R2-D2 mod for my son a couple years ago)," Carter says. "And when I saw a life-size replica of the speeder at Disneyland, I just knew it would make a great case mod."

Back To Jakku

Carter says he spent about two and a half months working on Rey's Speeder, and that he was on a pretty tight deadline. "I try to do as much research on my subject matter as possible, and apply that knowledge to the build," Carter says. "In reading about the backstory on how Rey built her speeder from salvaged starship parts, I wanted to take that same attitude towards this build. So whenever possible, I incorporated things from my own bone pile of old PC cases, such as the cut-down motherboard tray from an old Cooler Master case. Other brackets, chassis panels, and mesh were utilized, as well. One of the most popular features of the case was the salvage bag on the side of the speeder, where I added old PC components like a TNT2 video card, used liquid-cooling lines, an IDE cable, and an old Celeron processor slot 1 card. When I was at PDXLAN, people checking out the case had fun discovering all the old treasures!"

"This was my entry into Cooler Master's Case Mod World Series 2017, and it's my main gaming rig at home," he says. "Before starting this project, I knew I wanted to 3D-print as much of the case as possible. So I spent a lot of time building a virtual speeder and scaling it to house all the PC components inside. I found the 3D printer most helpful when I had to revise my reservoir mounts to accommodate the graphics card. It was so easy to go back into SketchUp, make an adjustment to the mounts, and simply print them out again. My fitment issue was resolved in just a few hours."

"Almost all the outer pieces were 3D-printed, save for a few found items and the saddle, which was modeled in foam and sculpting clay," Carter says. "As much as I wanted to 3D-print everything on this build, I had to go with what took the least amount of time due to the looming deadline. It was just quicker to form the saddle from a piece of foam insulation and cover that with sculpting clay."

Other than foam, clay, and 3D-printed parts, Carter says he used a piece of 4-inch-diameter dryer vent, which he cut down for the jet engine's heat shield. He also had to get creative to make the speeder "hover." "Rey's speeder uses devices called 'repulsorlifts' that enable it to hover above the ground," Carter says. "Making something hover in real life is quite the challenge, since I can't just skip down to the local hardware store and purchase a repulsorlift off the shelf. I had considered using strong magnets, but there aren't any currently available that can support anything over 20 pounds, so I had to settle for the next-best thing—tried and true engineering!" Carter devised a special cantilevered and weighted stand (he calls it "The Rebel Base") that can support the entire mod from just one end. "That way, there's nothing directly under the speeder holding it up, giving the illusion that it's hovering," Carter says.

Carter then covered the stand with a natural rock texture to minimize detraction from the overall look. He also did his own custom paint work, which was made somewhat more difficult given its 3D-printed parts. "Prepping 3D-printed parts for paint can be an arduous process, due to the layer-by-layer method in which they are produced," he says. "So first I had to smooth the surface of the parts by filling in all the layer lines with an epoxy putty. After priming and painting, I applied extensive weathering and aging effects to make the speeder bike look worn and faded from the baking sun. I was excited to finally get the opportunity to break out my airbrush and dirty up a perfectly good paint job—I have to admit, this gave me way too much satisfaction! Anyway,

to round out the theme, I always like to paint the peripherals to match, so the Corsair keyboard and mouse got the same weathering treatment."

The Fuel Cells Have Ruptured

Aside from an old TNT2, the parts Carter used in building Rey's Speeder include an Intel Core i7-7700K, an EVGA Z270 Stinger Mini-ITX mobo, an EVGA GeForce GTX 1080 FTW2 GAMING graphics card, 16GB of Crucial Ballistix DDR4, a Corsair SFX 600-watt PSU, and a pair of Crucial MX300 525GB SSDs. The cooling loop includes a PrimoChill CPU block, PrimoChill pump, PrimoChill reservoir, and PrimoChill rigid tubing and fittings. It also has an EKWB 240mm radiator and Corsair RGB case fans.

The peripherals Brian mentioned having painted to match (nobody does Attention To Detail like Carter) are a Corsair Gaming STRAFE RGB keyboard and an M65 Pro RGB mouse. He also included Corsair RGB lighting in the build.

Carter would like to think his sponsors: "Thanks to Crucial, Corsair, Intel, and especially EVGA and PrimoChill for giving me the honor of showcasing their awesome new products."

Carter says he has moved on to his next project already, which is hardly surprising for a guy who has close to 30 mods under his belt. "I'm working on an Overwatch-themed mod for Corsair," he says. "I plan on implementing more 3D-printed elements in it, as well."

Junkrat's peg-leg or Roadhog's enormous, protruding bellybutton: Who ya got? ∎
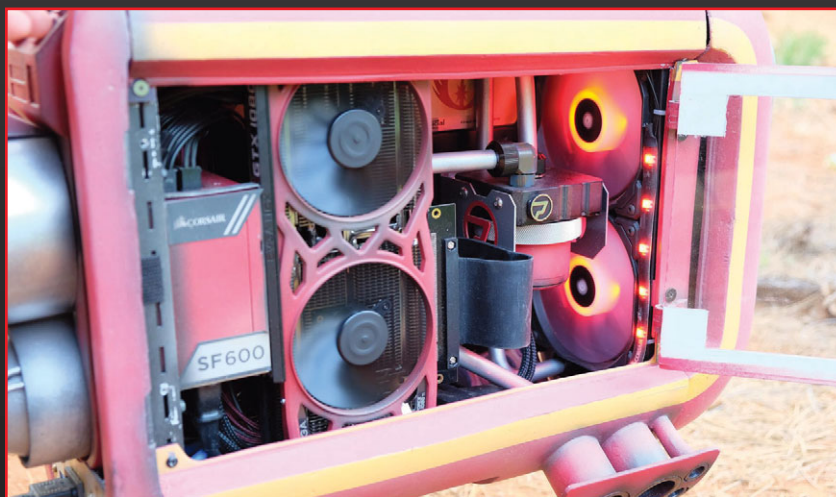
We Want Your Mod

Have a PC mod that will bring tears to our eyes? Email photos and a description to madreadermod@cpumag.com. If we choose your system as our "Mad Reader Mod," you'll win $1,500! (U.S. residents only, please.)

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PDXLAN 30

North(west)ern Exposure

PDXLAN 30 kicked off on Friday, July 21 at 6 p.m. and ran through Monday, July 24 at 6 p.m. In between were 72 amazing hours of gaming, contests, prize giveaways, catching up with friends, and much more. *CPU* was there, as we have been for a decade or more, and as usual we enjoyed being there for work nearly as much as attendees enjoyed attending. PDXLAN's unique blend of gaming and AFK activities means that something is pretty much always going on; this time around, AMD was on hand to talk about and demo its new Vega graphics cards, we judged another amazing mod contest, there was a massive prize raffle, and much more.

PDXLAN packed 'em in again for the 30th "main" event; attendance for the July LAN hit 550, and tickets (of course) sold out very quickly.

Attendees got a chance to kick the tires on AMD's new Vega graphics cards—and even got a chance to win one.

Picking a Top Five from all of the entries at a PDXLAN mod contest is never easy, but we managed to get it done once again. Read on to find out more about the mods that placed second through fifth; to find out more about Brian Carter's first-place "Rey's Speeder" mod (second from right, in case you missed it on the cover), check out our monthly "Mad Reader Mod" feature nearby in this issue.

Second

Some say that second place is the first loser, but looking at Jason "Spartan Mods"Pierce's Mrs. Spartan mod (so-named because he built it for his better half), we would have to disagree. This is a great-looking mod by any metric, and we loved it at first sight.

Based on Corsair's Graphite Series 600T mid-tower case, Mrs. Spartan is a love letter in PC form.

This mod is festooned with elaborate custom-built enhancements, starting with the lovebirds bolted on outside the left side and including the tree trunk displayed on the front panel, and much more inside.

Third

You'll see a pic of the third-place mod, Kegputer 2.0, in our "Modder Q&A" interview with Ben Lzicar elsewhere in this issue, but we thought we needed to show more here, as well. After all, it's not every day you see a computer that games like a champ AND dispenses ice-cold beer.

It looks like Kegputer's components are being cooled by frosty-cold beer with a nice head of foam, doesn't it? Sadly, this is an illusion, as apparently beer isn't good for complex, high-end PC components. The liquid you see in the bottom two-thirds of the case is acutally beer-colored coolant, and it's in a custom-made reservoir that looks like it encompasses the whole keg. It doesn't. Fear not, however: Kegputer does hold cold beer, in the form of cans that sit in a special refrigerated compartment at the top of the unit. They didn't show up at PDXLAN, because it's a dry event, but we have photographic proof, below and to the left.
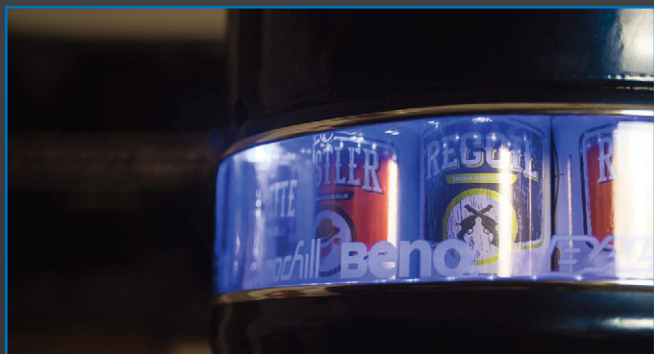
Lzicar has built some other very cool mods, but Kegputer and Kegputer 2.0 are the ones he's best known for.

Fourth & Fifth

Our fourth-place selection was lovingly crafted by none other than Dennis Leach, whose work is familiar to many who read *CPU*, most in the modding community, and everyone who frequents PDXLAN events.

Old Dream, by Dennis Leach (above and above right).

"This was the case I wanted to build and sell when Danger Den was still running," Leach says. It didn't work out back then, but Leach went ahead and built it now, and we're glad he did.

Fifth place went to Robert Sorensen and his Dragons mod (right and above right). "This mod was a great experience," Sorensen says. "I was born in the year of the dragon, as was my wife, so the theme of Dragons was easy and led to the choice of MSI for the motherboard and video cards. (It also helps that they make great products!)" Sorensen tells us that the Thermaltake Core P5's open concept made bending the hard tubing for his cooling loop simpler, and its wall-mount ability made it possible to craft the perfect stand to leave him with plenty of elbow room in the limited space at the LAN.

SAN LAN Summer Splash

eSports Spectacular In San Antonio

Back in our April issue, we introduced some readers to the resurgence of a cool eSports event in San Antonio called SAN LAN (those of you in the area likely already knew). We also pointed out that a summer event was upcoming, and on July 28, that event (SAN LAN Summer Splash) kicked off. Check-in started at 7 p.m., and people just hung out and gamed the first evening, plus there was a drawing for some cool prizes. The next morning at 8:30, team captains for the LAN's CS:GO and League of Legends teams met to go over scheduling, rules, and the like, and round robin tourneys began at 9. There was a *CPU* Case Mod Contest at 4 p.m., and gaming resumed until 9 p.m. The next day, tournaments continued to rage all the way through to 6 p.m., when awards were handed out and folks finally packed up their systems and headed out.

Spectators got in free on a first-come, first-served basis, and got to hang out in the Red Bull eSports Lounge, which was serving up free snacks and drinks. For $45, attendees could get a seat in the BYOC, and for another $5, they got an entry in either the CS:GO or LoL tournament. Attendees also had the option to donate to SAN LAN's campaign to help Gamers Outreach fund a GO Kart (a wheeled gaming cart) for The Children's Hospital of San Antonio.

Local artist Ray Roberts (@BoomFantasyArts) was at the LAN showing off some smokin' art based on Playerunknown's Battlegrounds. Case Mod Contest winners got prints of some of his work.
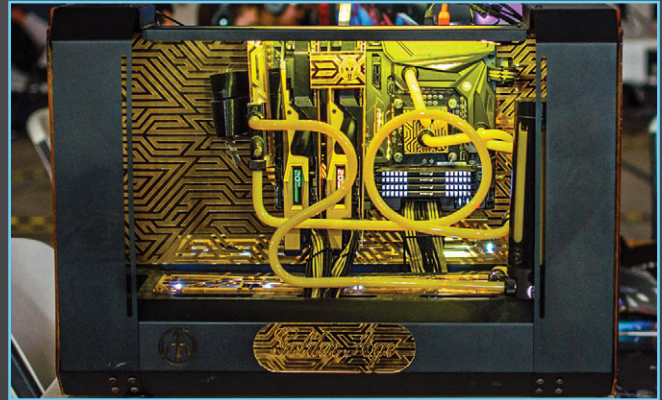

What's better than 47 hours of Counter-Strike: Global Offensive? Probably 48 hours of it, but SAN LAN had to end sometime.

Summer Splash Mods

Every good LAN party deserves a great mod contest, and SAN LAN is no exception. There were several cool mods on hand, including a couple we've seen at other events, so even though there can be only one winner, we decided we'd share pics of the top three for your perusal.

The second-place mod was Golden Age by Hassan Alaw of V1 Tech, whose work you may have seen on Intel's #ExpertMode Rig Wars.

First place went to Cameron Watkins and his excellent Fish Tank Mod, which we first saw at Dreamhack Austin back in April. And yes, those are real fish swimming around in there.
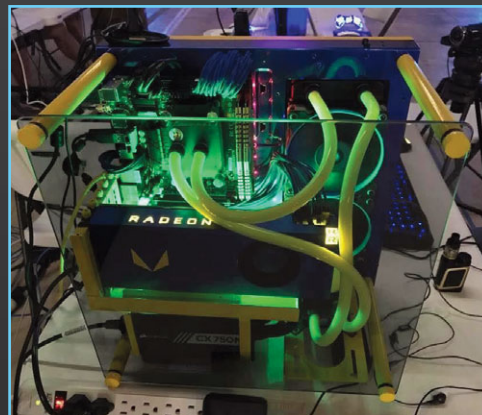
Matthew Hopkins' open-air mod featuring an AMD Radeon Vega card took third place.

Within moments of winning, the guys quickly dug into the latest issue of *CPU* for help planning their next projects.

The SAN LAN team put on a great LAN party.

AMD Ryzen Threadripper
Multicore, Megatasking Monsters Unleashed

If there's one arena where AMD has always excelled, it's naming its products. Over the years, we've been given AMD CPUs with code names and retail names that are equal parts menacing and awe-inspiring. We've had Sharptooth and Thunderbird, Sledgehammer and Clawhammer. Phenom, Bulldozer, Piledriver, and Black Editions for generations. Compared to a Wikipedia entry on towns and lakes in the Pacific Northwest, AMD's children sound like the types who posterize all the other kids on the playground basketball court and then stop to menacingly stroke their moustaches.

However, names themselves obviously don't do any of the computing. To bulldoze with Bulldozer or hammer with Sledgehammer, the underlying silicon does all the work. A CPU named "Laser-Shooting Velociraptor Riding A Megalodon" certainly sounds like it would ride roughshod over any benchmark in its path, but we all know the processor's underlying architecture, engineering, and overall execution determines its true power level.

With this in mind, AMD has asked enthusiasts to consider a trio of high-end chips with a name that makes a strong case for being the scariest ever: Threadripper. Better still, AMD has designed the two initial Ryzen Threadripper processors to do more than intimidate you into purchasing one. This latest effort marks AMD's first attempt in ages to challenge Intel for the overall performance crown.

"Ryzen Threadripper is the jolt of innovation that the high-end desktop customer was waiting for," says Jim Anderson, AMD Computing and Graphics group senior vice president and general manager.

Debuting in August, AMD's Ryzen Threadripper CPUs (you can call them "Threadripper" for short) are desktop CPUs unlike anything AMD has made. These processors are massive, with the top-of-line Threadripper 1950X having an astonishing 16 cores that can power through 32 threads simultaneously.

My Processor Can Beat Up Your Processor

Earlier this year, AMD finally unleashed CPUs based on its highly anticipated Zen microarchitecture. Officially "Zen" became "Ryzen," and the new Ryzen 7 1800X and 1700X led the way. Both of these 95W processors boasted eight physical cores along with the ability to chew on twice as many instruction threads simultaneously. The Ryzen 7 1800X had a base clock of 3.6GHz, while the 1700X hummed along at a slightly more modest 3.4GHz. The 1800X and 1700X, along with Ryzen 5 and Ryzen 3 CPUs, proved they were capable of trading punches with comparably priced Intel processors across a wide range of workloads.

Despite Ryzen's success, AMD still needed to find a way to truly contend with Intel's HEDT (high-end desktop) CPUs, such as the 10-core Core i9-7900X. The difference wasn't merely a matter of cores, either, as processors like the 7900X possess a quad-channel memory controller to greatly increase memory bandwidth, plus a whopping 44 PCIe 3.0 lanes for feeding high-end graphics cards, solid-state drives, and so forth. Ryzen 7 CPUs couldn't quite match these lofty specs. By comparison, the 1800X and 1700X are limited to a dual-channel memory controller and only 24 PCIe 3.0 lanes. Of course, this isn't an entirely fair comparison, given the fact that Intel's 7900X costs twice as much as AMD's 1800X, but it's meant to highlight AMD's lack of a comparable chip . . . until now.

With Threadripper, AMD is back in the driver's seat. The company's new flagship desktop processor is the Ryzen Threadripper 1950X, and it's a beast in every way. The 1950X is nearly overflowing with physical cores, a total of 16 to be exact, and by using SMT

(simultaneous multithreading) the 1950X is able to tackle up to 32 threads at a time. It has a 3.4GHz base clock and a Boost clock of 4GHz. The 1950X's little brother, the 1920X, is an impressive piece of silicon, too, with 12 cores (24 threads) running at a 3.5GHz base clock and 4GHz Boost clock.

Cores and clocks aside, AMD's biggest and baddest Threadrippers share some similarities. Both have a quad-channel memory controller, a first for AMD's desktop CPUs. Officially, the 1950X and 1920X have the same memory speed support as other Ryzen processors, DDR4-2667. The other key highlight for Threadripper is its 64 available PCIe 3.0 lanes, a simply staggering number and almost triple what the Ryzen 7 1800X and 1700X offer. Of that total, 60 are usable with up to seven PCIe 3.0 devices, so power users should have plenty of bandwidth for components that use the PCIe 3.0 bus. Other shared specs include a 32MB L3 cache, 512KB of L2 cache per core, an XFR (eXtended Frequency Range, another automated overclocking capability that can extend a limited number of cores beyond the processor's Boost clock provided it

detects an acceptable thermal load; for more information on AMD XFR, see this month's "State-Of-The-Art Standards" on page 29) clock of 4.2GHz, and 180W TDP. The "X" naturally denotes an unlocked multiplier, for overclockers who truly want to push Threadripper's boundaries. Like the rest of the Ryzen family, Threadripper CPUs are built on a 14nm FinFET process.

The third Threadripper to emerge, the 1900X has a higher base clock, 3.8GHz, but fewer cores, "only" eight. In some regards, the 1900X is the bridge between Ryzen 7 and Threadripper, since it shares the same number of cores as the 1800X and 1700X but has access to the Threadripper platform's quad-channel memory support and 64 PCIe lanes. The 1900X's 16MB L3 cache is consistent with Ryzen 7 and even most Ryzen 5 CPUs, yet it has a rated TDP of 180W. All Threadripper chips require AMD's new TR4 socket, as well, which illustrates how physically massive Threadripper CPUs are.

Super-Size Me

In order to cram so many cores into Threadripper, AMD needed to expand
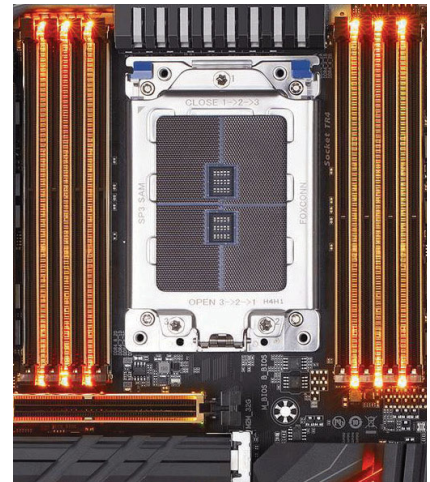
To truly appreciate the sheer size of Threadripper, look no further than AMD's new TR4 processor socket. To accommodate Threadripper's 4,094 pins, AMD needs a socket that's nearly as long as a motherboard's DIMM slots.

the CPU's physical footprint far beyond its Ryzen 7 CPUs. To make such a feat possible, AMD turned to its EPYC CPUs, the server side of the company's Zen architecture.

From time to time, hardware from the enterprise world crosses over into the realm of desktops. For example, Intel's 2008 Skulltrail platform was based on its Seaburg workstation chipset, and 2P (dual processor socket) motherboards occasionally make an appearance in the enthusiast market.

Threadripper has many similarities to AMD's EPYC server CPUs, although there are differences. For example, the TR4 socket is physically the same as EPYC's SP3 socket and has the same number of contacts, 4,094, yet the two are not cross-compatible. Further, EPYC CPUs can contain up to 32 physical cores, which helps explain what you'll find if you're courageous enough to de-lid your Threadripper.

Pop the Threadripper 1950X's hood, and it will look like four dies are hiding underneath. In reality, only two are active, each containing eight physical cores. On Threadripper, the other two are silicon blanks, while high-end EPYC processors contain four 8-core dies. Regardless of the

AMD Ryzen Threadripper Specs	AMD Ryzen Threadripper 1950X	AMD Ryzen Threadripper 1920X	AMD Ryzen Threadripper 1900X
THREADRIPPER, THREE WAYS			
Cores/Threads	16/32	12/24	8/16
Base/Boost/XFR clock	3.4GHz/4GHz/4.2GHz	3.5GHz/4GHz/4.2GHz	3.8GHz/4GHz/4.2GHz
L3 Cache	32MB	32MB	16MB
Process	14nm	14nm	14nm
PCIe 3.0 lanes	64	64	64
Max memory speed	DDR4-2667 (quad-channel)	DDR4-2667 (quad-channel)	DDR4-2667 (quad-channel)
Socket	AMD TR4	AMD TR4	AMD TR4
TDP	180W	180W	180W
Price	$999	$799	$549
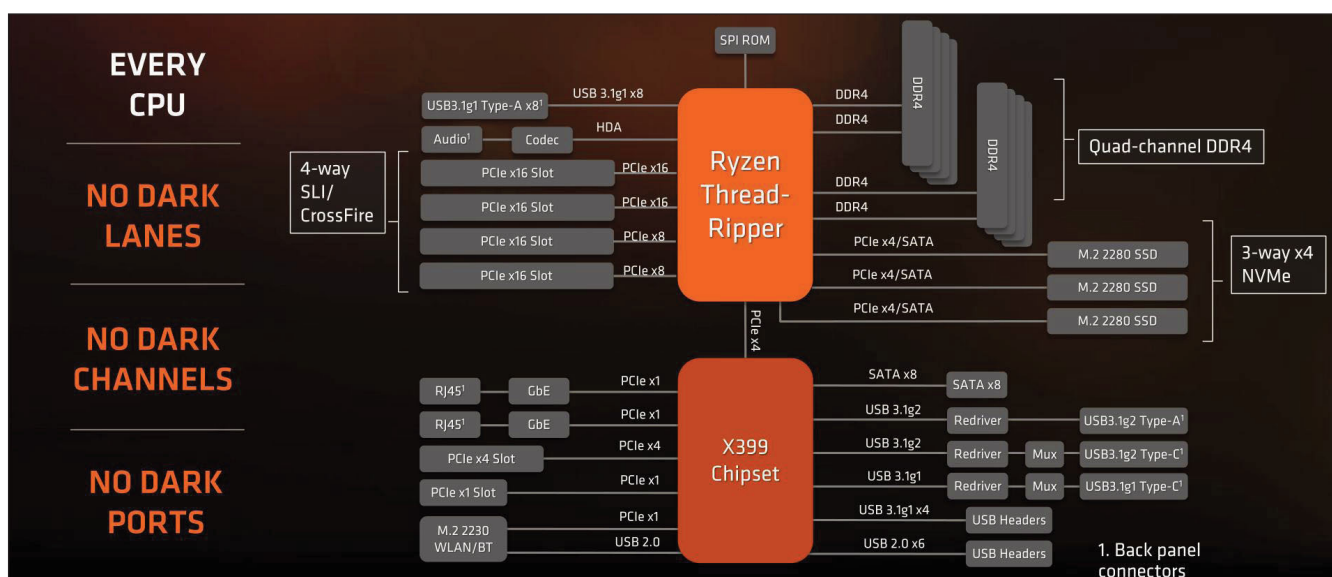
As you can see from this block diagram, Threadripper has a lot on its plate. Of course, we would expect nothing less from a platform that gives power users access to 60 usable PCIe 3.0 lanes. In addition to 4-way CrossFire/SLI (x16/x16/x8/x8), Threadripper supports up to three PCIe 3.0 x4 NVMe SSDs. Threadripper's remaining four PCIe 3.0 lanes link it to the X399 chipset, which handles things like USB connectivity, Gigabit Ethernet, etc.

number of active dies, AMD ties them together using its Infinity Fabric, the successor to HyperTransport.

A Unifying Thread

Over the years, we've relied on different advancements and technologies to continue taking CPU and system performance to new heights. That could involve simply increasing frequencies, adding more cores, or shrinking the manufacturing process to add more transistors. After splitting Threadripper's (and EPYC's) cores across multiple dies, AMD developed a new interconnect called Infinity Fabric to ensure high-speed transmission between separate processor dies, as well as other components.

For a basic understanding of Infinity Fabric, think of the Threadripper 1950X not as a single 16-core CPU but rather two 8-core processors sharing a single package. These are Ryzen's 8-core Zeppelin dies, which further break down into two core complexes (CCXs) of four cores. With its pair of Zeppelin dies, Threadripper has a MCM (multicore module), where the separate Zeppelin dies must communicate

with each other with as much bandwidth and as little latency as possible. That's where Infinity Fabric comes in.

Infinity Fabric is a single, unified protocol that connects together cores on the same die, multiple separate dies, and multiple sockets. And don't think of sockets in the traditional sense; these could also be a system's graphics cards (provided they're AMD GPUs, of course), which reveals AMD's master plan. Its Vega GPUs use Infinity Fabric, too, theoretically boosting performance when all are working in concert. AMD cites a die-to-die bi-directional bandwidth of 102.22GBps between the 1950X's two dies. Threadripper's processor dies can access DRAM with 78ns latency for near memory, which is the memory connected to the die, and 133ns for far memory, the DRAM that's connected to the opposite die.

Game Time

We live in an age where cores count more than clocks, but having a CPU with an outrageous number of cores doesn't mean it will destroy every workload you put in its path. These processors rely on

software that's written to take advantage of multiple cores. You can see this in POV-Ray and Cinebench whenever we benchmark a processor, as both of these tests scale remarkably well with the number of cores a processor has.

Games, on the other hand, are regularly made for quad- or octo-core CPUs, not a 12- or 16-core Threadripper. On occasion, an excessive number of cores can result in bad thread scheduling, which drops performance. It's possible a game might not run at all.

AMD fixes this problem with Game Mode. Effectively disabling one of Threadripper's working dies, Game Mode presents the 1950X as an eight-core, 16-thread processor, which plays nicer with games. Game mode also uses the active CPU die's local DRAM.

Start Ripping

AMD Ryzen Threadripper 1950X and 1920X are available now, and at the time of this writing the 1900X was scheduled to be released August 31. Team it with an X399 motherboard and get ready to bludgeon some benchmarks. ∎

Modder Q&A: Ben Lzicar

If You Build It, They Will Drink

Ben "Bennyboy1337" Lzicar's "Caged Heart" mod appeared in our December 2015 issue's "Mad Reader Mod" feature, and it's an excellent example of the form. But he's probably better known for his Kegputer, which is just what it sounds like: a beer keg with a computer in it. (And yes, it still dispenses beer.) Lzicar also does some work producing videos and other creative for Micron's Crucial and Ballistix product lines, and is a long-time regular at PDXLAN in Portland.

Q: How long have you been modding, and how many mods have you built at this point?

BL: I have been modding as long as I've been building computers, back since 2003. I would say I have built around a total of 20 modded machines since I started 15 years ago.

Q: Is it fair to say the Kegputer is the most well-known and widely recognized mod you've built?

BL: For sure, I built that thing back in 2010 and I still get questions about it to this day. To date, I still think I'm the only person to build a computer that dispenses beer.

Q: What was your first mod project, and how did it turn out?

BL: The first PC I ever built completely on my own was back in 2003. I used an old, hideous Compaq case from my parent's old machine, I cut a hole in the side and mounted an acrylic window, painted the case blue and yellow, then mounted some blue LED lights I

bought from RadioShack. My friends called it "the Pokémon case" because of the colors and teased me about it all the time. I've obviously upped my game since then; they don't make fun of my builds anymore!

Q: How many Kegputers of beer do you go through at PDXLAN?

BL: Uh . . . well, PDXLAN is a dry LAN, so no beer allowed. But when at home on the weekend, a six-pack of a local IPA has me set for a night of gaming.

Q: How is Kegputer 2.0 different from the original Kegputer?

BL: Well, 2.0 makes it look like the parts are submersed in beer, thanks to a custom circle-shaped reservoir I made and some custom PrimoChill beer-colored coolant. I also have a mini-fridge up top that holds beer cans, which is more practical than refilling a beer keg every weekend.

Caged Heart, Lzicar's December 2015 Mad Reader Mod-winning project.

Lzicar's best-known mod, Kegputer.

The latest beer keg computer, Kegputer 2.0.

Q: If you could pick a beer sponsor for Kegputer 2.0, which one would it be?

BL: I had Payette Brewing sponsor my last build and I love their beer, so if I didn't have them for the next one I would probably go with another local favorite, like Woodland Empire or Sockeye Brewing. These are Idaho microbrews by the way. The Boise area has a ton of great brewers.

Q: Which was more difficult to build, the Kegputer or Caged Heart?

BL: The heart actually took longer to build but the Kegputer was more difficult just because of the scope of the project. With most builds, I am typically teaching myself to do something I've never done before, be it: casting silicone, powder coating, making a reservoir, or using a laser machine.

Q: How long have you been going to PDXLAN, and what's your favorite PDXLAN story?

BL: I've been going for eight years. Favorite story was the time my friend's backpack with a brand-new Core i7 he won at the raffle blew off the roof rack on my car while driving home. We thought the CPU and his keyboard and mouse that were in the bag were goners, but thanks to a *CPU* magazine that had my name and address on it, an awesome National Guardsman found the bag eight months later! Surprisingly, the CPU and keyboard still worked, even after sitting on the side of an Oregon road through the whole winter.

Q: What's your favorite mod out of all the mods you've built, and why?

BL: Probably the Midnight Tower build I did for a friend of mine. It is just a really clean and aesthetically pleasing build; beautiful oak panels, great powder-coated frame, killer loop. You can check out the build on the Ballistix YouTube channel (www.youtube.com/watch?v=RnAEGJDg8fc).

Q: What would you say is the strongest part of your modding game?

BL: My ability to think outside the box. Don't get me wrong, I like clean case builds, but to me a scratch build that's never been done before is really where it's at. If I can redefine what it means to be a computer, then I have done my job.

Q: What's the weakest part, and why?

BL: Making my builds at the last minute. I don't know why I always do this, but for some reason I decide to build an epic computer a few months before PDXLAN; this means I'm pressuring myself to get the project completed instead of taking my time to ensure it is as good as it can be.

Q: What's up next now that Kegputer 2.0 is done?

BL: I might actually do a traditional case build. There is a CaseLabs Bullet sitting in my office right now that's begging to have a system built in it.

Q: It's time for Five Quick Questions!

1) Intel or AMD?

Intel. I still love AMD though!

2) Best Spider-Man: Tom Holland or Tobey Maguire?

I had a horrible date experience watching Spider-Man when I was in middle school, so Holland all the way.

3) Counter-Strike: GO or Overwatch?

Factorio? I honestly don't play either game that much. Counter-Strike: Source was my jam back in my college days though, so I guess I would have to go with CS:GO.

4) Powder coat or paint booth?

Powder coat all the way. Once you go powder you never go back.

5) PDXLAN July or PDXLAN November?

November. It's more laid back, and seeing a bunch of gamers raise money for a local homeless shelter is always great. ∎

Midnight Tower, Lzicar's favorite build.

In The Loop
Expand Your AIO

Last month, we covered an expert's take on how to convert an off-the-shelf All-In-One liquid cooler into a custom loop by pulling out the pipes and adding a bigger radiator, graphics card block, standalone reservoir, and flexible or hardline tubing. But this month, we're getting our feet wet (hopefully not literally) by trying it for ourselves with the help of a bunch of gear from Alphacool.

Part Picking

Not all AIOs are good candidates for conversion to a custom loop. Many combine aluminum radiators with copper waterblocks and brass fittings, but avoid the galvanic corrosion that plagues mixed-metal environments by adding corrosion inhibitors such as ethylene glycol, propylene glycol, or glycerin to the coolant. We're planning on using plain old distilled water, so sticking with copper (the waterblock and our upgraded radiator are copper) and brass (the Alphacool fittings we got are brass) is ideal.

As we relayed in last month's interview with Elliot Shiver, PrimoChill's Senior Technical H20 Specialist, the CPU waterblock/integrated pump is the most useful and valuable item in your AIO. For the subject of this experiment, we chose Alphacool's Eisbaer 120 CPU, which is an AIO that features the company's innovative quick-release connector for easily adding a GPU waterblock, such as the Alphacool Eiswolf.

You might think that an AIO bundled with a 120mm radiator wouldn't ship with a pump that's powerful enough to handle the upgrade to a 360mm radiator, like the NexXxoS ST30 Full Copper Radiator 360 we selected for our upgrade. According to the Eisbaer specifications, however, the DC-LT Ultra Low Noise Ceramic 12V waterblock/pump (capable of pushing 70 liters per hour) is the same unit used in the Eisbaer 140, 240,

Only use tools to loosen fittings, never to tighten them.

280, 360, and 420. That means it should be more than powerful enough for our loop.

The other big benefit of going with the Eisbaer is the fact that it is compatible with G1/4-threaded fittings. The rest of our parts list consists of eight G1/4-threaded Alphacool Eiszapfen 16/10mm flexible tubing compression fittings, a half-dozen G1/4-threaded 90-degree angled adapters, the Alphacool NexXxoS GPX graphics card waterblock with backplate (we got a model that was designed to work with our NVIDIA GeForce GTX 1080 Ti Founders Edition), the Alphacool Eisbecher 250mm Acetal Reservoir, and two meters of appropriate-sized flexible tubing.

Crank & Drain

The first step is to disassemble your AIO. If it's currently installed in your PC, take it out and clean the thermal paste off of both the waterblock and processor heat spreader. The Eisbaer comes with tubing, quick-disconnect adapters, and a series of G1/4-inch fittings, all of which we'll discard for this expansion project. With a bucket handy to catch the coolant, we used a pair of pliers to gently unscrew the fittings on the Eisbaer's waterblock/pump unit until it was free of the AIO's radiator, and set them both aside to drain. In addition to the waterblock/pump's intake and output ports, the Eisbaer also features a fill port that that makes it easy to keep your loop topped off and avoid the damage that can occur if the pump runs dry. We removed the fill port cover to help drain the existing coolant from inside the unit's built-in reservoir.

With the waterblock/pump dry and a pair of 90-degree compression fittings installed finger-tight, we used the Eisbaer's AM4 mounting bracket to affix it to the socket on

Given the right components, converting your AIO into a custom loop is not only possible, it's easy.

Once we had finished bleeding the air out of the loop, we were ready to rock.

the GIGABYTE motherboard in our system. If you're worried about excess coolant leaking out, we recommend rolling up paper towels and sticking them into the open ports.

Get A Cooler GPU

The next thing we did was install the Alphacool NexXxoS GPX waterblock onto our graphics card. This entails removing the air cooler from the NVIDIA GeForce GTX 1080 Ti Founder Edition we're using, which is a lengthy and involved process of its own. Although the graphics card waterblock comes with straightforward illustrated instructions, there are no instructions for removing the existing air cooler. If you've never disassembled an air-cooled graphics card, we recommend starting with the backplate facing up (or the backside of the card if there is no backplate) and simply removing any screw you can see. Next, flip the card over and unscrew any screws in the top side of the card's cooler that appear to attach it to the PCB. Don't forget to remove the screws on the back I/O bracket. You shouldn't need to remove the fans from the cooler to proceed.

When separating your graphics card's PCB from the cooler, make sure to carefully unplug any fan or LED headers before wrenching the two apart. Usually these cables are only a couple of inches long and don't provide you much room in which to work. If you have any hopes of reinstalling the air cooler, treat these connectors and cables with care. Graphics card waterblocks rarely require connection to these headers.

When installing any third-party waterblock on your graphics card, just remember that in most cases you'll be voiding the unit's warranty. Take your time, follow the install instructions, and be patient. One slip of a screw driver and your expensive graphics card could be damaged beyond repair.

Order From Chaos

With the waterblock-equipped graphics card and processor installed in our system, the next step was to mount the new radiator and reservoir. The CaseLabs case we used for this project doesn't have a mesh front or top panels, so we were forced to use the bottom of the case for air intake instead of the front or top, as is traditional. We installed the 360mm radiator, with the fans oriented as intake fans, in the bottom of the case. Because we're installing a liquid-cooled graphics card, we kept the radiator's in and out ports on the right side of the system, which ensured we didn't have excessively long runs of tubing crossing in front of the graphics card.

There are no built-in reservoir-mounting holes on the interior of this case, so we measured, marked, and drilled a quartet of holes to mount the reservoir to the right of the motherboard tray. With the reservoir mounted and oriented, our next job was to determine to loop order.

When it comes time to determine the path of the coolant, our primary concern is to ensure that the Eisbaer waterblock/pump is pulling liquid in directly from the reservoir. As a result, the pump will always have ready access to plenty of liquid with little resistance, even when operating at its highest speed. Due to the layout of the rest of our liquid-cooling components, our coolant path choices were fairly limited.

Determining which of our waterblock/pump unit's ports are in and out was a vital step. The Eisbaer has its intake on the right and the output on the left. As a result, the coolant in our system flows from the reservoir to the Eisbaer waterblock/pump unit, to the Alphacool NexXxoS GPX waterblock on our GTX 1080 Ti, to the NexXxoS ST30 Full Copper Radiator 360, and then back to the Alphacool Eisbecher 250mm Acetal Reservoir via its top cap. Once we had the flexible tubing cut and spanning between each of these components in order, it was time to fill the system, check for leaks, painstakingly bleed out the air, and monitor our temperatures. When all that checked out, the system was ready to go, and it looks great. ■

Dominant DDR4

Memory Kits That Fuel Performance

Prices for DRAM are highly unpredictable. Unfortunately for system builders, memory costs have risen dramatically over the course of 2017. A recent report from DRAMeXchange indicates that the average PC DRAM contract price (the cost for shipments over a specific time frame, often ranging from two weeks to a month) increased nearly 40% sequentially in first quarter of 2017, 10% sequentially in the second quarter, and another 4.6% between June and July. In short, system memory cost has more than doubled since the end of 2016. 16GB kits that might have cost you $75 last year are often more than $170 today, while 32GB kits generally cost more than $300. Now that we've prepped you for sticker shock, here are a few important factors you'll want to consider before purchasing system memory and comparing the modules in our buyers guide.

AMD Ryzen Ready
Ryzen processors introduced DDR4 support to AMD platforms, and when Ryzen was first released in March, motherboard and memory makers were still ironing out the kinks with overclocked DDR4 speeds. Some hardware combinations, for example, wouldn't POST with the memory operating at the module's fastest rated speed and latency. DDR4 compatibility is better now that companies have had time to perform more extensive testing. Still, we recommend that anyone building on the AMD platform select a DDR4 kit that's been qualified by the motherboard manufacturer. Many of the modules in our guide are designed to work on AMD platforms at the maximum factory speed.

Quad-Channel Upgrade
Before the recent annoucements of AMD's X399 and Intel's X299 platform, the aging Intel X99 chipset was the only way for consumers to utilize quad-channel DDR4 memory. Quad-channel kits provide a sizeable bandwidth increase over memory in a dual-channel setup, because the CPU has simultaneous access to four memory modules. And the new AMD and Intel platforms allow for speedy DDR4 modules that further push the performance of enthusiast rigs.

16GB Single Module
The DDR4 standard expands single module capacity up to 16GB, and although it took a few years, most memory manufacturers now offer a few kits with 16GB sticks. If you have a need for extreme memory, such as loading up 128GB of memory on an Intel X299 or AMD X399 motherboard, or simply want to reach 32GB without filling up all your DIMM slots, a kit with 16GB modules might be for you.

GeIL 16GB AMD EDITION EVO SPEAR DDR4-2400

$130.99
www.geil.com

Why You'll Dig It: The EVO SPEAR series is compatible with almost all builds, including small form factor systems, thanks to a low-profile heat spreader. And as a member of GeIL's AMD EDITION, the memory modules have been tested specifically for the Ryzen processor platform. GeIL designs the EVO SPEAR series for gamers in the market for speedy, yet cost-efficient, kits of DDR4 memory. This 16GB kit, for example, operates at 2,400MHz and costs only $130.99. The timings of 16-16-16-36 are also respectable, considering the EVO SPEAR's price tag. GeIL also offers the EVO SPEAR series at speeds up to 3,466MHz for Intel's Z270 and X299 series chipsets.

Who Should Apply: AMD builders who want to ensure compatibility with their new Ryzen or Ryzen Threadripper system.

Capacity: 16GB (two 8GB modules)
Speed: 2400MHz
Timings: 16-16-16-36

HyperX 32GB Predator DDR4-3000

$370
www.hyperxgaming.com

Why You'll Dig It: The Predator lineup is currently available at speeds up to DDR4-3600MHz, thanks in part to a well-designed heat spreader that keeps the module cool under extreme loads. This DDR4-3000 kit boasts two XMP configurations (DDR4-3000 and DDR4-2666), as well as a JEDEC DDR4-2400 profile. You'll just need to select the fastest profile supported by your motherboard and you're ready to go. We also like the fierce look of the black heat spreader, with its teeth-like fins. This quad-channel kit includes four 8GB modules with relatively aggressive timings of 15-17-17-36—at both the DDR4-3000 and DDR4-2666 XMP settings. In our system testing with SiSoftware Sandra's Memory Bandwidth benchmark, the quad-channel kit delivered excellent speeds of nearly 48GBps.

Who Should Apply: Builders interested in high-speed kit with low latency timings. We also like HyperX's variety of kit capacities and speeds with the Predator series.

Capacity: 32GB (four 8GB modules)
Speed: 3,000MHz
Timings: 15-17-17-36

KIT OF **4**

Crucial 16GB Ballistix Sport LT DDR4-2400

$171.99
www.ballistixgaming.com

Why You'll Dig It: Available with red, gray, or white heat spreaders, the Ballistix Sport LT DDR4-2400 modules feature a "digital camo" design and black PCB that will fit into most power user builds. Crucial offers both two- and four-module kits to support both dual- and quad-channel configurations. The 16GB Ballistix Sport LT DDR4-2400 boasts four 4GB modules. The XMP 2.0 profile on the 16GB Ballistix Sport LT DDR4-2400 runs at the low latency of 16-16-16-39. All of the modules in the Ballistix Sport LT series operate at 1.2V, so they'll be compatible with current voltage requirements of Intel and AMD motherboards. Like all Crucial memory, this kit is rigorously tested and backed by a lifetime warranty.

Who Should Apply: Builders looking for an affordable quad-channel DDR4 kit that combines great looks with solid performance and long-term reliability.

Capacity: 16GB (four 4GB modules)
Speed: 2,4000MHz
Timings: 16-16-16-39

ADATA 32GB SPECTRIX D40 DDR4-3200

$359.99
www.xpg.com

Why You'll Dig It: The SPECTRIX D40 series features RGB lighting and has been fully tested with ASUS AURA Sync software. The bright LED strip sits atop the heat spreader, and the angular curves of the LED strip give it an aggressive look. This quad-channel kit operates at DDR4-3200 speeds, and ADATA indicates that the XPG SPECTRIX D40 lineup will eventually operate at up to 4,000MHz. ADATA includes an Intel XMP 2.0 configuration, and the company says the kit is also compatible with AMD AM4 motherboards. When installed on Intel's X299 platform, the kit defaults to a DDR4-2666Mhz speed, rather than the DDR4-2400MHz or DDR4-2133 baseline typical of DDR4 kits. Similar to other ADATA memory modules, the SPECTRIX D40 modules are backed by a lifetime warranty. For long-term reliability, ADATA designs the SPECTRIX D40 series with a 10-layer PCB.

Who Should Apply: DIY enthusiasts who want to enhance the look of their build with bright RGB LEDs that draw attention to their system memory.

Capacity: 32GB (four 8GB modules)
Speed: 3,200MHz
Timings: 16-18-18-36

Patriot 16GB Signature Line DDR-2400

$140.98
www.patriotmemory.com

Why You'll Dig It: Patriot's Signature Line is designed for value-minded builders who want stable memory performance. This 16GB DDR4-2400 kit, for instance, is compatible with Intel 100 and 200 series chipsets, as well as AMD 300 series platforms. The two 8GB modules, of course, will also support modern dual-channel chipsets. For compatibility, the 16GB Signature Line 2400MHz operate at DDR4's preferred 1.2V power. Like other Patriot memory modules, the Signature Line comes with Patriot's free customer service and features a lifetime warranty. The DDR4-2400 modules are certainly not the fastest available, but few 16GB kits will cost less than $141.

Who Should Apply: Users building mainstream systems who desire a hassle-free, plug-and-play kit.

Capacity: 16GB (two 8GB modules)
Speed: 2,400MHz
Timings: 17-17-17-39
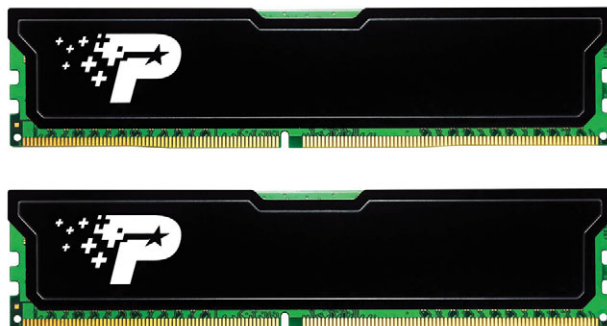
G.SKILL 32GB Trident Z DDR4-4000

$512.99
gskill.com

Why You'll Dig It: G.SKILL has long been at the forefront of DRAM speed, and the Trident Z series is often where you'll see G.SKILL's groundbreaking DDR4 modules. This 32GB kit can operate at up to 4,000MHz and has been designed for use on Intel's Skylake-X and Kaby Lake-X series processors. And with four 8GB modules, the kit can take full advantage of the quad-channel memory controller built into the Skylake-X processor. Most all X299 motherboards support DDR4 at this kit's incredible 4,000MHz speed. The 32GB kit operates with timings of 18-19-19-39 and a voltage of 1.35V when using the Intel XMP 4,000MHz settings.

Who Should Apply: Enthusiasts with the latest-and-greatest components who want to bring out the most memory bandwidth and speed from their system memory.

Capacity: 32GB (four 8GB modules)
Speed: 4,000MHz
Timings: 18-19-19-39
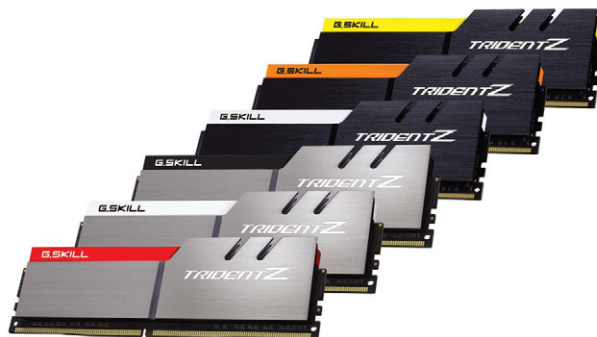
HyperX 16GB FURY DDR4-2666

$164
www.hyperxgaming.com

Why You'll Dig It: HyperX designs the FURY lineup as a cost-effective way to complement the DDR4 capabilities of AMD and Intel's latest chipsets. The $164 16GB FURY DDR4-2666 kit is a good example, as the two 8GB modules offer decent performance, and you won't have to pay the premium associated with higher speed DDR4 modules. For optimal compatibility, HyperX engineers both the XMP and JEDEC profiles to operate at only 1.2V. The HyperX memory team has also performed extensive compatibility testing with AMD's X370 and B350 chipsets, and the company expects the FURY DDR4-2666 modules to operate at programmed speeds and timings without issue. In our testing, the kit worked great on MSI's X370 GAMING TITANIUM and AORUS GA-X370-Gaming K7, posting speeds around 27GBps in Sisoftware Sandra's Memory Bandwidth test.

Who Should Apply: Gamers on a budget who need to upgrade system memory and DRAM performance.

Capacity: 16GB (two 8GB modules)
Speed: 2,666MHz
Timings: 16-18-18-36

Corsair 16GB Vengeance LPX DDR4-2400

$174.99
www.corsair.com

Why You'll Dig It: DDR4-2400 kits are supported by almost all motherboards on the market and represent a decent speed upgrade over base DDR4-2133 modules. Corsair's 16GB Vengeance LPX DDR4-2400 kit boasts a pair of 8GB modules with timings of 16-16-16-39. Corsair compatibility tests the Vengeance LPX kits with AMD Ryzen series motherboards to ensure it'll work on the latest platforms. Looking for something a bit faster? Corsair also offers the Vengeance LPX lineup in speeds up to 4,333MHz. Quad-channel kits are also available, if you're looking to take full advantage of AMD's X399 or Intel's X299 platform.

Who Should Apply: Enthusiasts on a budget who want a kit that will work in most any build.

Capacity: 16GB (two 8GB modules)
Speed: 2400MHz
Timings: 16-16-16-39
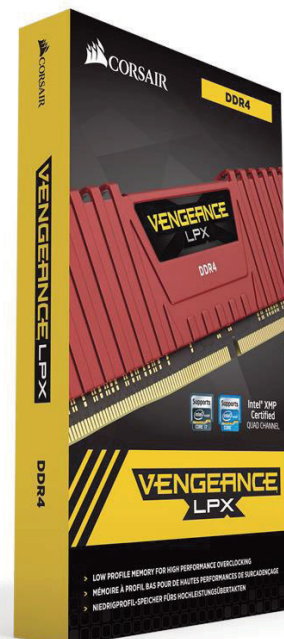
# Patriot 16GB VIPER 4 DDR4-3600

$189.99
www.patriotmemory.com

Why You'll Dig It: Patriot's Viper 4 series meets all the requirements we demand from DRAM. This dual-channel kit boasts an aggressive latency of 17-19-19-39, while operating at DDR4-3600 speed. The Viper 4 series is able to reach such latencies and speeds with a custom-designed, high performance heat spreader that keeps the modules cool under load. The red heat spreader's tall fins also stand out inside a build. Patriot has a wide selection of dual-channel kits with the Viper 4 lineup, as well as quad-channel kits, if you're building around an HEDT platform. Patriot hand-tests and validates all of these memory modules before packaging them up and shipping them out the door, greatly reducing the likelihood that you wind up holding a bum stick. Beyond that, Patriot backs its Viper 4 series memory with a limited lifetime warranty.

Who Should Apply: Multimedia enthusiasts who want to lower video render times and gamers who wish to improve frame rates.

Capacity: 16GB (two 8GB modules)
Speed: 3,600MHz
Timings: 17-19-19-39
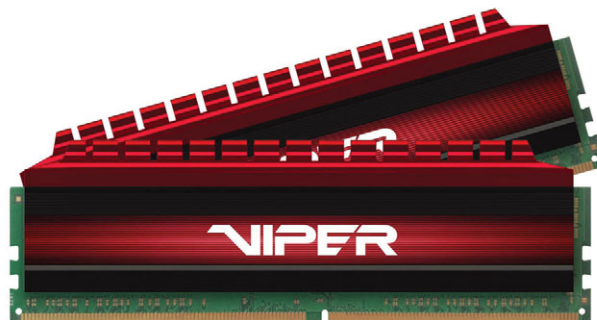
G.SKILL 16GB Trident Z RGB DDR4-3200

$168.99
www.gskill.com

Why You'll Dig It: Trident Z RGB models feature a vivid RGB light bar on top of the heat spreader, and the light bar is capable of generating a fluid rainbow wave, among other effects and single color options. This dual-channel kit isn't the fastest Trident Z RGB option, but it does sit in a sweet spot for pricing and speed at $168.99. One thing we like about the Trident Z RGB series is that, compared to some other RGB memory, there's no need for RGB cables running to and from the modules. If your motherboard doesn't provide a software utility to configure the Trident Z RGB colors, G.SKILL also offers a beta software you can install to control effects and color. To improve reliability and stability, the Trident Z RGB modules are built with a 10-layer PCB, and each kit is tested on a wide range of motherboards.

Who Should Apply: Power users who want LED memory that syncs up system lighting and effects with the other RGB components on their system.

Capacity: 16GB (two 8GB modules)
Speed: 3,200MHz
Timings: 16-18-18-38
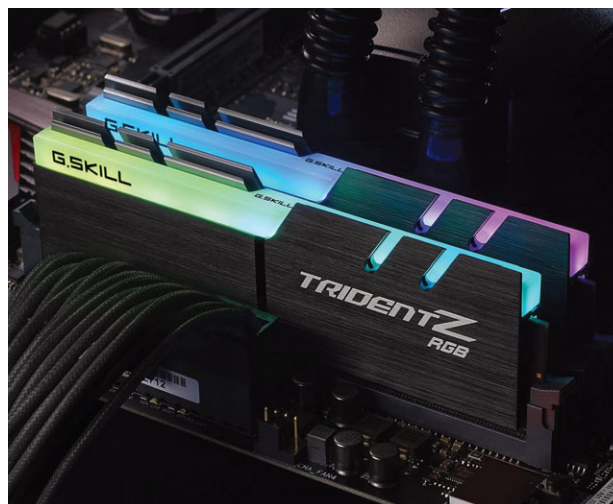
GeIL 16GB EVO X DDR4-3000

$145.99
www.geil.com

Why You'll Dig It: GeIL's EXO X DDR4-3000 kit features RGB illumination along the top of the heat spreader, and GeIL includes an RGB extension cable to more easily sync lighting effects with other components, such as the motherboard. GeIL EXO X series memory supports RGB lighting control via ASUS AURA Sync, ASRock AURA RGB LED, GIGABYTE/AORUS RGB Fusion, and MSI Mystic Light. The 80cm extension cable is long enough that you'll be able to reach 4-pin RGB headers near the bottom of the board, or LED lights at the top of a case. GeIL designs the two 8GB modules to operate at timings of 15-17-17-35 at the 3,000MHz speed.

Who Should Apply: Modders in the market for memory with RGB LEDs that will help to visually enhance a system's interior.

Capacity: 16GB (two 8GB modules)
Speed: 3000MHz
Timings: 15-17-17-35

Crucial 32GB Ballistix Elite DDR4-3200

$379.99
www.ballistixgaming.com

Why You'll Dig It: This 32GB quad-channel, 3,200MHz kit is ideally-suited to gamers and enthusiasts. The modules feature built-in thermal sensors that report to Crucial's Ballistix M.O.D. (Memory Overview Display) utility and let you keep an eye on temperatures in real-time. The memory chips are attached to a black PCB, and the anodized matte black aluminum heat spreaders feature a distinctive profile that looks like a Picatinny rail, for a military look and feel that's as functional as it is attractive. We also like that the all-black modules match most motherboards' PCB and heatsinks. This memory's optimized XMP latencies (15-16-16) should provide a noticeable improvement in your system's overall responsiveness and deliver faster frame rates.

Who Should Apply: System builders who want to monitor temperatures for their system memory.

Capacity: 32GB (four 8GB modules)
Speed: 3,200MHz
Timings: 15-16-16
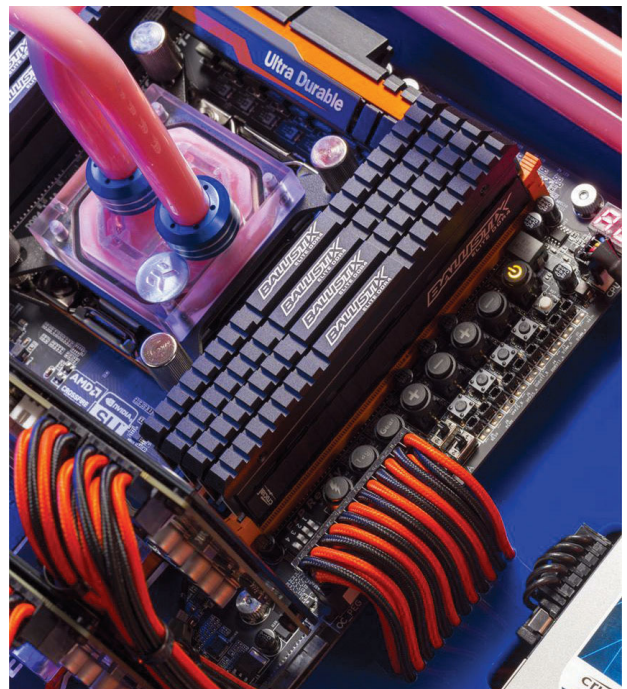
Corsair 16GB Vengeance LPX DDR4-3200
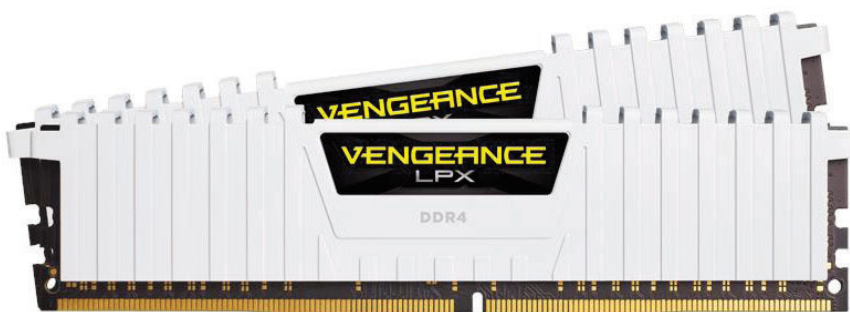
$179.99
www.corsair.com

Why You'll Dig It: This high performance kit has been designed for motherboards running AMD Ryzen series processors. Corsair follows an extensive compatibility testing process that includes most every AMD Ryzen series motherboard available. To quickly dissipate heat, the Vengeance LPX modules feature a pure aluminum heat spreader. Corsair also offers the Vengeance LPX in a few different colors, including white, black, blue, and red. Vengeance LPX modules feature an eight layer PCB, which helps to manage heat at faster speeds. The 16GB kit consists of two 8GB modules with XMP settings of 16-18-18-36 at the 3,200MHz speed. We also like that the Vengeance LPX modules feature a low-profile design to improve compatibility with air coolers and small form factor builds.

Who Should Apply: Power users looking for a versatile DDR4 kit that's built with performance and reliability in mind.

Capacity: 16GB (two 8GB modules)
Speed: 3,200MHz
Timings: 16-18-18-36

ADATA 16GB XPG Z1 DDR4-3000

$179.99
www.xpg.com

Why You'll Dig It: The XPG ZI modules feature a heat spreader that resembles a jet wing. It's more than just an attractive look, because the heat spreader also boasts excellent cooling by utilizing ADATA's Thermal Conductive Technology. Each module is designed with a 10-layer PCB and two ounces of copper to effectively reduce electric resistance and consume less power, which greatly enhances the quality of signal transfer. ADATA offers the XPG Z1 lineup in red, gold, white, and black colors. We particularly like the gold modules, as they are a striking color you don't typically see inside a case. This DDR4-3000 dual-channel kit, as with other modules in the XPG Z1 lineup, has been officially validated by AMD as AM4/Ryzen compatible, so you won't have to worry about POST issues at the rated speed.

Who Should Apply: Power users in need of a dual-channel kit that will work on almost any platform.

Capacity: 16GB (two 8GB modules)
Speed: 3,000MHz
Timings: 16-16-16-36

## Patriot 16GB Viper Elite DDR4-2666

$157.99
www.patriotmemory.com

Why You'll Dig It: Patriot's Viper Elite kits deliver excellent performance. This set of two 8GB modules, for example, operates at up to 2666MHz with timings of 16-17-17-36. Patriot offers the 16GB Viper Elite DDR4-2666 modules in striking red, understated gray, or bright blue (pictured here). The color options make it easy to complement or brighten up the interior of your build. Patriot has also done extensive compatibility testing on AMD's X370 and B370 chipsets and has developed a full list of compatible DDR4 parts, and this kit is among the modules ideal for use with Ryzen processors.

Who Should Apply: Power users who want their system and memory to perform at the top of its game.

Capacity: 16GB (two 8GB modules)
Speed: 2,666MHz
Timings: 16-17-17-36
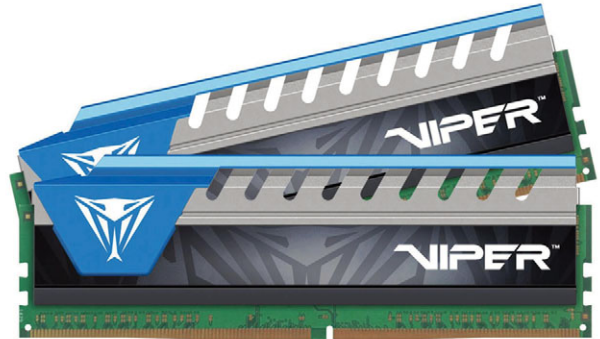
Corsair 32GB Vengeance LPX DDR4-2400

$329.99
www.corsair.com

Why You'll Dig It: Do you have a serious need for system memory and want the flexibility to further upgrade in the future? This 32GB Vengeance kit consists of two 16GB modules, ideal for maximizing memory capacity without using up all of the DIMM slots on a motherboard. The high-capacity modules are also a good option for small form factor builds where the motherboard might only offer two DIMM slots. Corsair designs the 32GB Vengeance LPX kit to operate at 2,400MHz with a tested latency of 16-16-16-39 and voltage of 1.2V. Similar to other Corsair memory lineups, the Vengeance LPX modules are backed by a limited lifetime warranty, and each IC has been screened to optimize performance potential.

Who Should Apply: Enthusiasts and creative professionals who need to pack a lot of memory capacity into their system's DIMM slots.

Capacity: 32GB (two 16GB modules)
Speed: 2,400MHz
Timings: 16-16-16-39

Kit	MSRP	Speed	XMP Timings	Voltage	Capacity	LED	Warranty
G.SKILL 32GB Trident Z DDR4-4000	$512.99	4,000MHz	18-19-19-39	1.35V	32GB (4x8GB)	None	Limited Lifetime
Crucial 32GB Ballistix Elite DDR4-3200	$379.99	3,200MHz	16-18-18-36	1.35V	32GB (4x8GB)	None	Limited Lifetime
HyperX 32GB Predator DDR4-3000	$370	3,000MHz	15-17-17-36	1.35V	32GB (4x8GB)	None	Limited Lifetime
ADATA 32GB XPG SPECTRIX D40 DDR4-3200	$359.99	3,200MHz	16-18-18-36	1.35V	32GB (4x8GB)	RGB	Limited Lifetime
Corsair 32GB Vengeance LPX DDR4-2400	$334.99	2,400MHz	16-16-16-39	1.2V	32GB (2x16GB)	None	Limited Lifetime
Patriot 16GB VIPER 4 DDR4-3600	$189.99	3,600MHz	17-19-19-39	1.35V	16GB (2x8GB)	None	Limited Lifetime
ADATA 16GB XPG Z1 DDR4-3000	$179.99	3,000MHz	16-16-16-36	1.35V	16GB (2x8GB)	None	Limited Lifetime
Corsair 16GB Vengeance LPX DDR4-3200	$179.99	3,200MHz	16-18-18-36	1.35V	16GB (2x8GB)	None	Limited Lifetime
Corsair 16GB Vengeance LPX DDR4-2400	$174.99	2,400MHz	16-16-16-39	1.2V	16GB (2x8GB)	None	Limited Lifetime
Crucial 16GB Ballistix Sport LT DDR4-2400	$171.99	2,400MHz	16-16-16-39	1.2V	16GB (4x4GB)	None	Limited Lifetime
G.SKILL 16GB Trident Z RGB DDR4-3200	$168.99	3,200MHz	16-18-18-38	1.35V	16GB (2x8GB)	RGB	Limited Lifetime
HyperX 16GB FURY DDR4-2666	$164	2,666MHz	16-18-18-36	1.2V	16GB (2x8GB)	None	Limited Lifetime
Patriot 16GB Viper Elite DDR4-2666	$157.99	2,666MHz	16-17-17-36	1.2V	16GB (2x8GB)	None	Limited Lifetime
GeIL 16GB EVO X DDR4-3000	$145.99	3,000MHz	15-17-17-35	1.35V	16GB (2x8GB)	RGB	Limited Lifetime
Patriot 16GB Signature Line 2400MHz	$140.98	2,400MHz	17-17-17-39	1.2V	16GB (2x8GB)	None	Limited Lifetime
GeIL 16GB AMD EDITION EVO SPEAR DDR4-2400	$130.99	2,400MHz	16-16-16-36	1.2V	16GB (2x8GB)	None	Limited Lifetime

Build A Software RAID With Windows 10 Storage Spaces
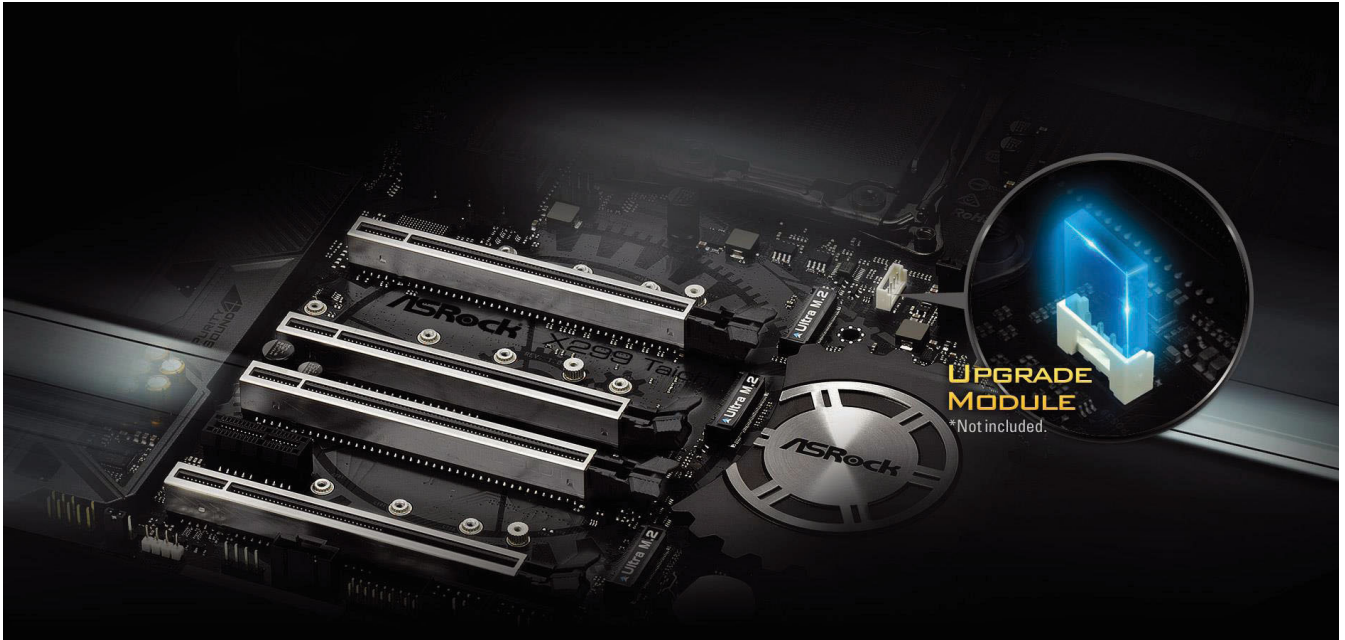
Looking for hardware-based NVMe RAID support? Intel VROC (Virtual RAID On CPU) is your only real option.

It's 2017, and the ability to combine two or more storage devices into a single large pool for the purposes of increasing the performance, automating data redundancy, or both, is a technology that many of us take for granted. It's true, SATA-based RAID (Redundant Array of Independent Disks, or if you prefer, Inexpensive Disks) has been around seemingly since the dawn of the specification, but M.2-based RAID is still rather wet behind the ears.

You might think that as long as you have multiple available M.2 slots on your motherboard, or if you invest in something like the ASUS Hyper M.2 PCIe card with four M.2 slots on a PCIe x16 expansion card, you can populate them all with NVMe drives and enjoy a mind-numbingly fast RAID array, in a variety of configurations. Not so fast.

On older platforms, PCIe lanes are at a premium, but things aren't much better with the latest hardware. On AMD's new X399 platform with a Ryzen Threadripper chip installed, there's currently no way to run RAID on NVMe drives, though of course SATA-based RAID is supported. As we went to press, however, AMD was reportedly working on something to address the issue.

On Intel's X299 platform, NVMe-based RAID is possible, but fraught with caveats. To get it to work on our ASRock X299 Taichi motherboard, for instance, you'll need to purchase a standard or premium VROC (Virtual RAID On CPU) key if you plan to use anything more complicated than RAID 0, and the keys are rumored to cost between $99 and possibly up to a whopping $299. You may also be limited to using Intel NVMe drives only. Again, we don't know the full story as we went to press because keys were not yet available, and Intel has yet to fully flesh-out VROC's requirements.

Given the half-baked state of hardware-based NVMe RAID, you could be forgiven for assuming your current options are to go SATA or go home. Again, not so fast. There's another option you may not have considered, and that is to create and run a software-based RAID array.

Soft RAID

When you take the hardware limitations out of the RAID equation, your options open up considerably. For those running one or more servers, particularly where data redundancy is mission critical, RAID isn't just a
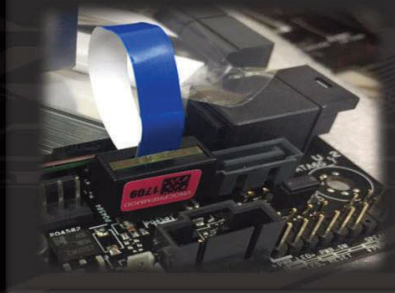
SUPERB PERFORMANCE

INTEL VROC SUPPORT
How to enable VROC
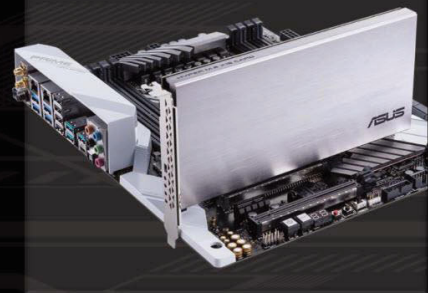
1. Purchase the key.

2. Insert into ASUS' X299 MBs & use a SKL-X CPU.

3. Install up to 4 Intel SSDs in the Hyper M.2 X 16 Card.

H/W key	VROC function
No need	Raid 0
Standard	Raid 0/Raid 1
Premium	Raid 0/Raid 1/Raid 5

- Only Intel SSDs can use Intel VROC.
- Intel VROC does not support 3rd party SSDs.

/ISUS
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VROC hasn't been fully fleshed out as we went to press, but you'll need to purchase a key from Intel to unlock anything better than RAID 0.

handy feature, it's a necessity. That's why many common server OSes support file systems that have built-in logical volume manager capabilities.

One such example is a file system called ZFS, which is the native file system used in Solaris and Illumos, the open source version of Sun's OpenSolaris. ZFS is also supported on FreeBSD and Linux. If you're running a server and using ZFS as your default file system, you can easily implement RAID 0, RAID 1, and the equivalent of RAID 5 single-parity, RAID 6 double-parity, and even RAID 7 for triple-parity. Despite being a proprietary Oracle format, the OpenZFS umbrella project is continuing to develop and support the open-source branch.

Back when we wrote about building your own NAS box, we used FreeNAS for the system's OS, which also supports the ZFS file system. Here, a ZFS-based RAID array delivers a high degree of data integrity and prevents silent data corruption that users can frequently encounter when running very large and very fast databases. It's possible to use ZFS with a hardware RAID controller, however you need to choose the JBOD option on the controller to enable the ZFS file system to not only detect errors and corruption, but recover the corrupt sectors as well.

If you're curious about implementing a software-based RAID on your general-purpose PC, you may be surprised to learn that Windows 10 has a built-in utility that makes creating a virtual RAID array fast and simple, using any combination of two or more SATA, NVMe, SAS, USB 2.0, or USB 3.0 storage devices. The utility is called Storage Spaces, and it is capable of replicating traditional hardware-based RAID's speed-multiplying capabilities and hardened data redundancy in a variety of configurations. This utility

> You may be surprised to learn that Windows 10 has a built-in utility that makes creating a virutal RAID array fast and simple.

lets you manage multiple internal or external hard drives and SSDs as a single "storage space" with a capacity that you can shrink or grow dynamically, replacing or adding drives as needed, without losing any data in the process. In this month's article, we'll walk you through the process of setting up and using a simple storage space.
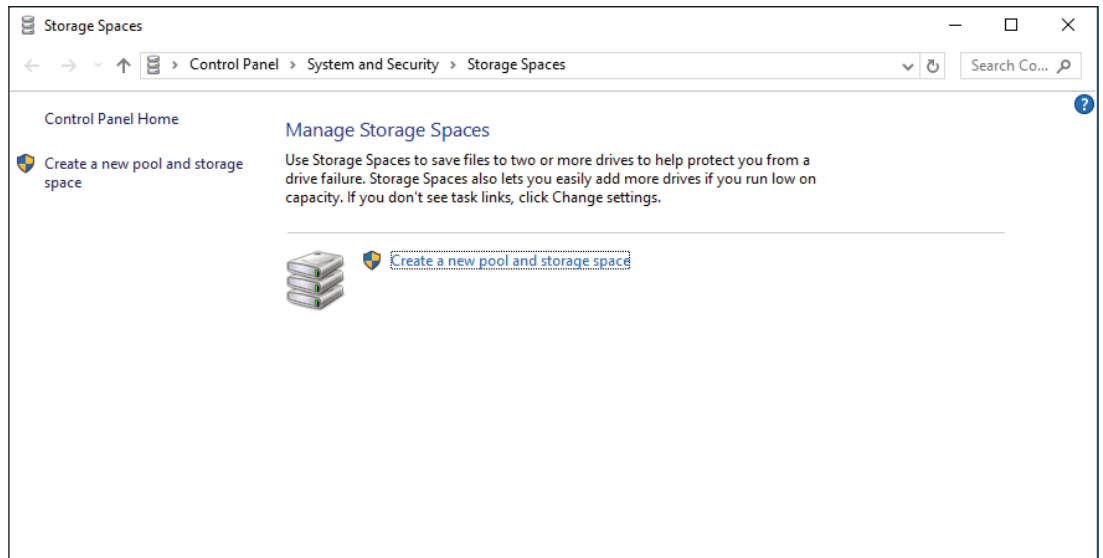
Windows 10 users have access to a built-in software RAID utility called Storage Spaces.

Hardware Prerequisites

For our test system, we're using an Intel Core i7-7820X installed in the ASRock X299 Taichi with 32GB Corsair Vengeance LED DDR4-3200. The OS drive is a 480GB Patriot Hellfire NVMe SSD. We're running Windows 10 Enterprise Edition, but the Storage Spaces utility is also available on all consumer versions of Win10. We've connected a new 500GB HP S700 SSD and a positively ancient 240GB OCZ Vertex 3 to a pair of the ASRock X299 Taichi's SATA ports. You may want to ensure the SATA devices you plan to use are driven by the chipset's primary SATA controller as we encountered problems when using ports that
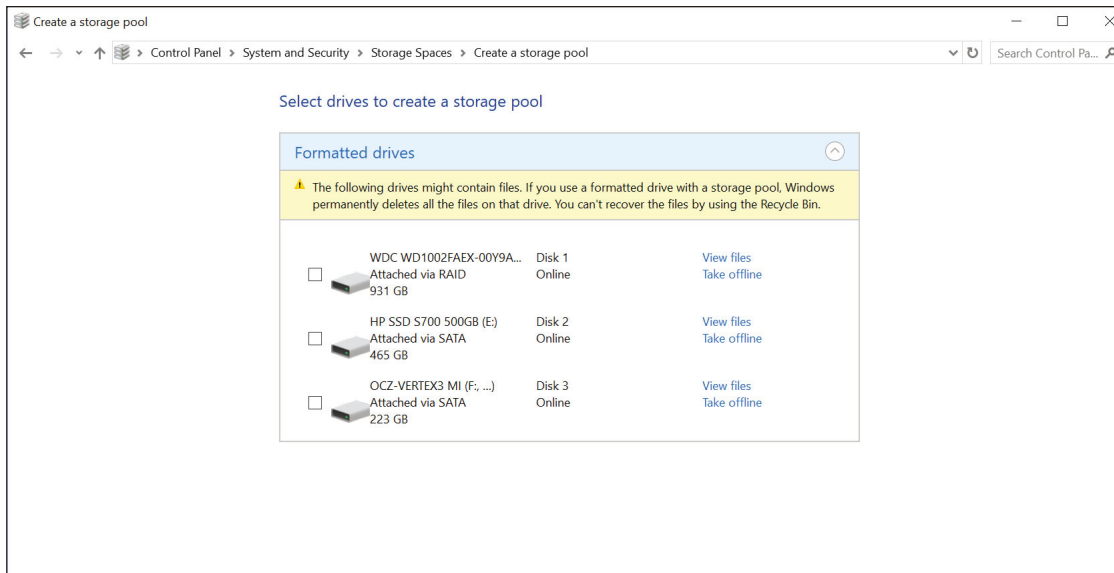
correspond to a 3rd-party SATA controller on the motherboard, but more on that later. We also connected a 64GB USB 3.0 Kingston HyperX Savage thumb drive to one of the motherboard's external USB 3.0

ports in an attempt to determine how versatile Storage Spaces can be.

Before we got started, we formatted both of the SSDs and the thumb drive. If you're planning to reappropriate drives, make sure to take anything
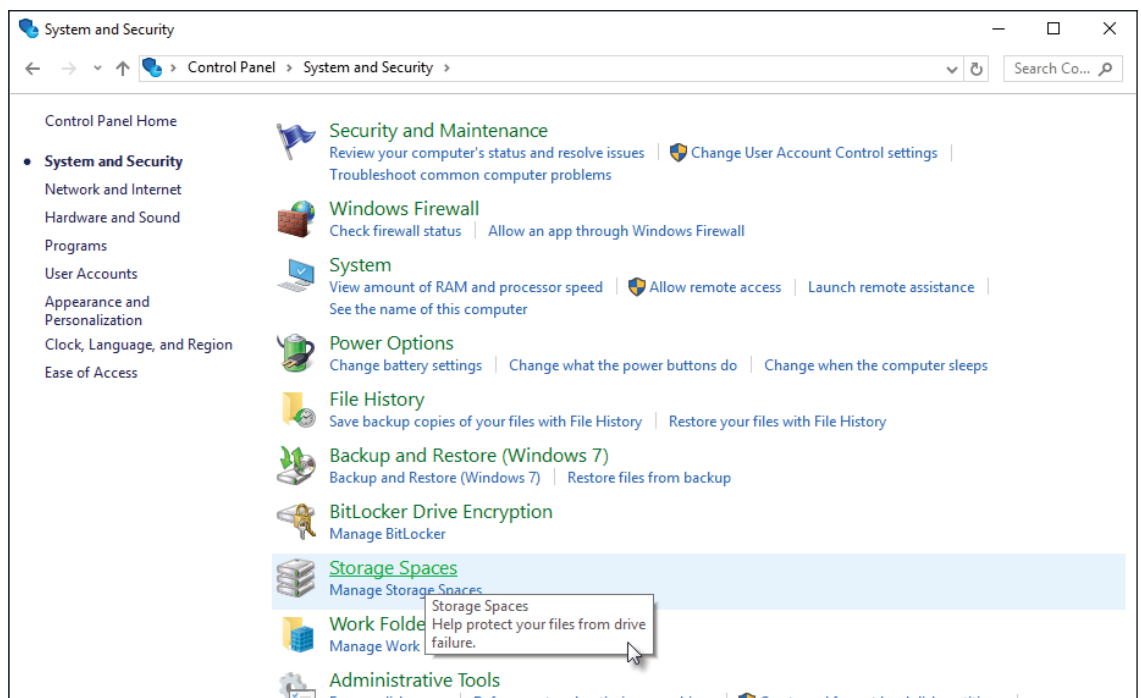
The Control Panel, under the System and Security heading, is where you'll find Storage Spaces.

Create a storage pool

Control Panel › System and Security › Storage Spaces › Create a storage pool

Select drives to create a storage pool

Formatted drives

⚠ The following drives might contain files. If you use a formatted drive with a storage pool, Windows permanently deletes all the files on that drive. You can't recover the files by using the Recycle Bin.

☐	WDC WD1002FAEX-00Y9A... Attached via RAID 931 GB	Disk 1 Online	View files Take offline
☐	HP SSD S700 500GB (E:) Attached via SATA 465 GB	Disk 2 Online	View files Take offline
☐	OCZ-VERTEX3 MI (F:, ...) Attached via SATA 223 GB	Disk 3 Online	View files Take offline

If you have two or more drives that can be used with the utility, they will appear in the Formatted or Unformatted Drive boxes.

important off of them before you proceed with setting up the Storage Space. If you don't format the drives ahead of time, the utility will do it for you during the process, but there are advantages to manually formatting in advance.

Storage Spaces

The easiest way to access this utility is to click into the search box on the taskbar, type storage spaces, then press ENTER. Depending on your version of Win10, you may be able to access the utility from the Control Panel by right-clicking the Start button, clicking Control Panel, System And Security, and then clicking Storage Spaces. Next, click Create A New Pool And Storage Space and then click Yes when the UAC prompt appears.

If no drives connected to the system are compatible with Storage Spaces, you'll be informed on the Select Drives page. It was at this point that we determined that the USB thumb drive we had formatted did not show up as an option for inclusion in our new storage pool. None of the half-dozen USB 2.0 or 3.0 thumb drives we plugged in were detected, whether formatted as exFAT or NTFS. It's possible that an external hard drive

attached via USB would appear as an available option, but we didn't have one on hand to test this theory.

On the Select Drives To Create A Storage Pool screen, the HP S700 and the OCZ Vertex 3 SSDs did show up, as well as our 1TB backup drive that we have no plans to add to the storage pool. Because we formatted the pair of SSDs in advance, we didn't need to worry about moving data. If you have a new unformatted drive, or if you used Windows' Disk Management utility to delete partitions and leave the drive as unallocated space, then those drives will appear in the Unformatted Drives box.

Keep in mind, any drive that appears in the Formatted Drives box will be eligible for use in a storage pool, but may not be empty of useful data. Hyperlinks to the left of each detected drive let you view files or take the device offline. To proceed, we clicked the checkboxes in front of the HP and OCZ drives and then clicked the Create Pool button at the bottom of the page.

At this point, the Storage Spaces utility proceeds to format the drives. As we mentioned above, we initially had our two SSDs attached to SATA ports driven by a 3rd-party SATA controller, which resulted in a "Can't create the pool, check the drive connections and try again

Keep in mind, any drive that appears in the Formatted Drives box will be eligible for use in a storage pool, but may not be empty of useful data.

LOADING ZONE

(0x00000032)" error. After connecting the drives to a pair of ports managed by the Intel chipset, the pool was created without incident.

On the following screen, you have the opportunity to choose a resiliency type, size, and name for the new storage pool. By default, the utility names the pool "Storage Space," but you can input a different name by clicking into the text box and typing. We named our pool, "Backup," left the drive letter assignment at the default, and also left the File System option at the default NTFS setting. The alternative file system option is REFS, which refers to the Resilient File System capable of enabling Windows to automatically maintain data integrity and help prevent data loss in the event of a drive failure.
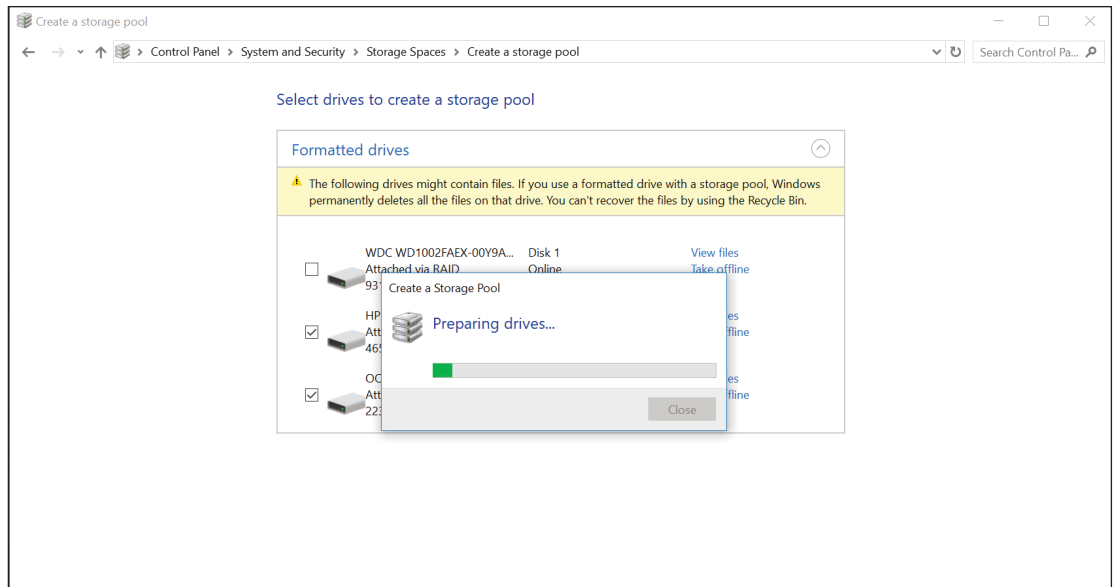
When you create a pool, the drives will be wiped and formatted, so make sure anything on them that you value is backed up elsewhere first.
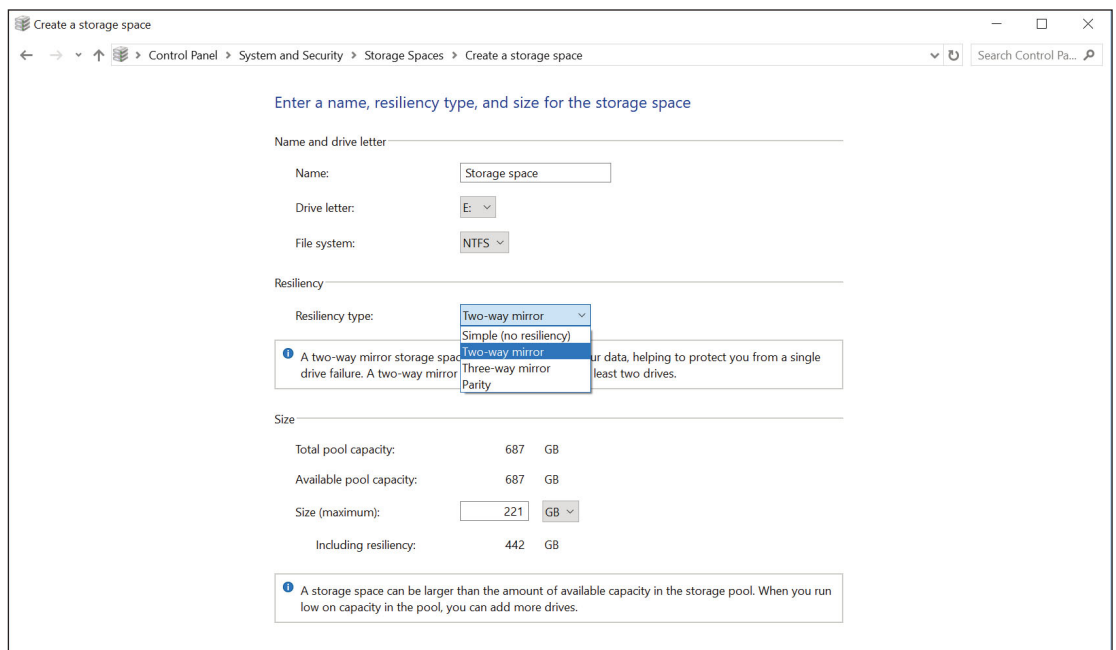
A two-way mirror offers a good balance of performance and redundancy, so it's the option we chose.

Resiliency Options

Choosing a resiliency type for your pool is perhaps the most important step you'll take in this tutorial. Click the drop-down menu to select from Simple (no resiliency), Two-way Mirror, Three-way Mirror, and Parity.

The Simple space option is good for those who are most concerned with improving the performance of their storage pool. This is effectively a RAID 0 setup. Although performance will increase and the capacity of your devices will be combined, the primary drawback is that the chances you'll encounter a drive failure are multiplied by the number of drives in the pool. A Simple space composed of three drives, for instance, is three times as likely to fail as running a single drive. According to Microsoft, this sort of
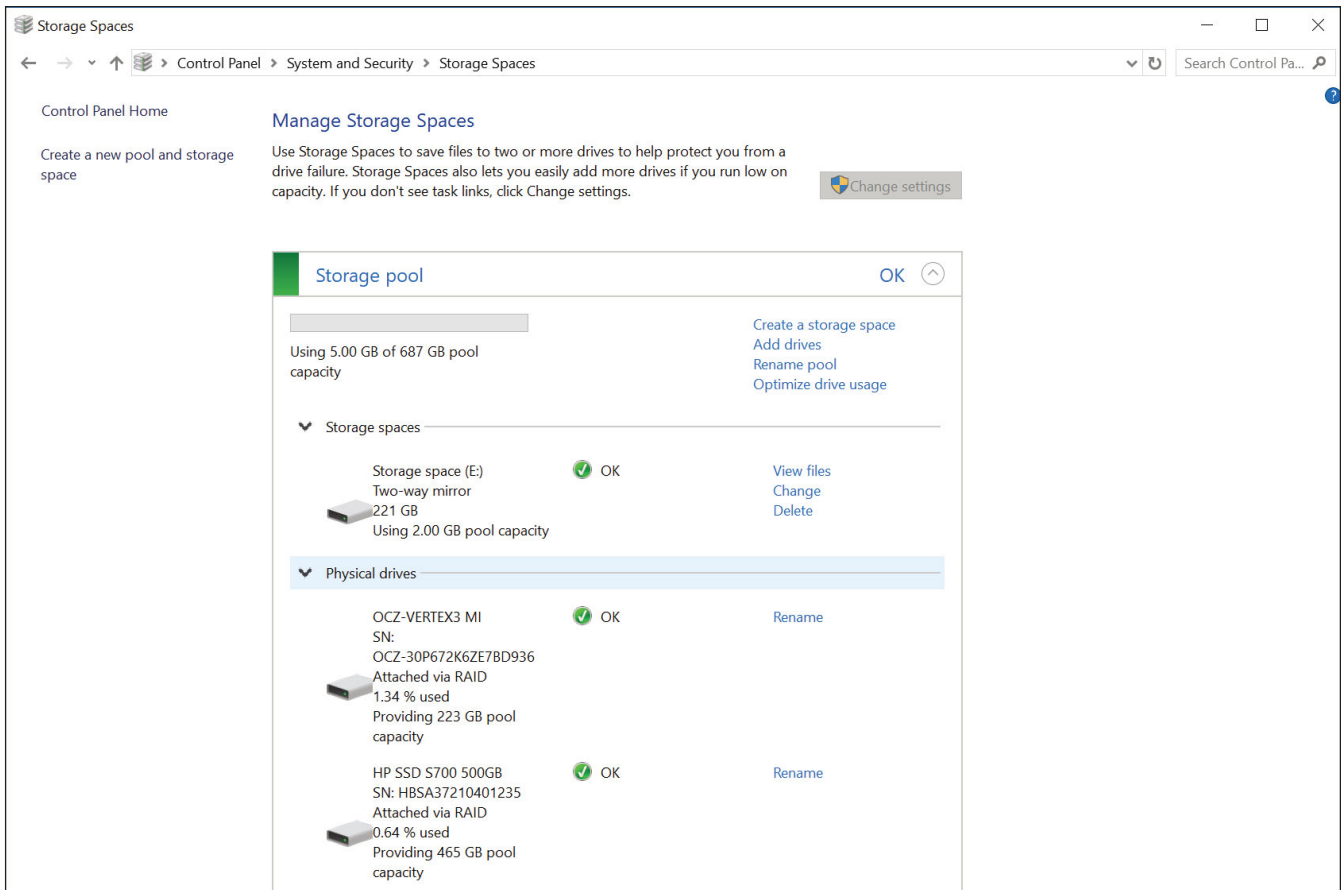
Depending on the type you selected, your Storage Space can be self-repairing, allowing for drive replacement and capacity upgrades on the fly.

storage pool is best for temporary files, such as video rendering files, image editor scratch files, and intermediary compiler object files. You'll need a minimum of two drives to create a Simple space with any appreciable performance improvement.

Mirror spaces, either two-way (requires at least two-drives, makes two copies of every file, and can tolerate one drive failure) or three-way (requires at least five drives, makes three copies of files, and can tolerate two drive failures), are designed to balance increases in speed against added data resiliency. Microsoft recommends this type of storage pool to anyone looking to use a storage space for virtually any type of data that you value highly, such as general purpose files, backups, and more. Mirror spaces are also good for those who only have

two drives to work with, but want to maintain data integrity. Of course, any storage pool that relies on stashing copies of files across multiple drives will slash the combined capacity of your drives by at least half.

Choosing the Parity option does nothing for performance, but focuses on

data resiliency above all else. Again multiple copies of your files will be created across multiple drives, letting your data remain in-tact even if one drive fails in a three-drive parity pool or two drives fail in a seven-drive parity pool. Microsoft recommends selecting this option for archival data and music and videos libraries.

Choosing the Parity option does nothing for performance, but focuses on data resiliency above all else.

Juggling Capacity

To get the best of both worlds with our pair of SSDs, we selected the Two-way Mirror option from the dropdown menu. The various pool sizes appear below. For our configuration, the Total Pool Capacity was listed as 687GB, which was identical to the Available Pool Capacity. Even though we chose an option that includes file redundancy, the Storage Spaces gives us close to, but not exactly, the combined capacity of our 500 and 240GB drives. That's all thanks to Storage Spaces' support for thin provisioning, or a logical drive whose capacity is totally independent of the physical drives.

You'll want to avoid filling up your storage pool, however, because once a physical drive becomes full, it'll automatically unmount itself. When approximately 70% of the physical drive space is consumed, the utility will begin prompting you to add drives to keep pace. If you get one of these warning prompts, click the Change Settings button on the Manage Storage Spaces panel and click Add Drives. After you add a drive (remember, keep all SATA drives on the same controller) the utility will begin "repairing," or distributing files depending on the options you selected when you created the pool.

You can input a number into the Size text box to dictate the upper limits of your thin provisioning, and the capacity including resiliency (doubled files) appears below, auto-matically. For instance, if we set our maximum size to 400GB, then the including resiliency num-ber appears as 800GB. To actually achieve this level of capacity, we'd need to ultimately upgrade the storage pool to at least two 500GB drives (there is some capacity-slashing overhead involved).

Once the capacities look good, click the Create Storage Space button to complete the operation. The utility will then format the array and open the empty File Explorer window that corresponds to the new storage space. Now just add files.

Making The Most Of Storage Spaces

To create the most effective and useful Storage Space, it's best to use drives that are all of the same type, capacity, and speed. To put it simply, creating a pool from mixed drives will deliver mixed results. For instance, an external USB 2.0 hard drive will considerably slow down your array of 6GBps SATA SSDs when combined into a single storage pool. Our array comprised of a 500GB SSD and a 240GB SSD is less-than-ideal because it'll only take about 84GB of unique files in our two-way mirrored storage pool before we get a low capacity warning.

As we continue to use our new soft RAID, we'll report back on anything we encounter going forward. Due to time and space constraints, we didn't get a chance to cover the performance of our software RAID, let alone compare it to the performance of a similar hardware-based RAID configuration, but we'll definitely be looking into this at a later date. For now at least, we can say that Windows Storage Spaces is easy to use, and there's lot of potential for enthusiast and novice users alike. ∎

Your Raid Refresher

There's a lot of RAID talk in this article, so let's go over some of the most popular types of RAID arrays that hardware-based RAID controllers tend to support. Again, RAID combines two or more storage devices to form a larger storage volume that offers faster data read/write operations, built-in redundancy and the ability to self-repair, or all of the above.

A RAID 0 array, for instance, is one of the most simple forms of RAID that combines the capacities of all drives. The files written on such an array are split into small chunks and distributed across the drives, which lets them all perform read and write commands simultaneously, for dramatically better performance than a single drive can deliver. The drawback of a RAID 0 array is that if any individual drive fails, so does the whole array.

RAID 1, 5, and 10 arrays, on the other hand, offer excellent redundancy designed to be recoverable in the event of a drive failure. RAID 1 requires at least two drives, RAID 5 (striped with distributed parity) requires three, and RAID 10 requires a minimum of four drives to operate, but it offers the best performance and data security of the RAID options mentioned here. Any configuration with built-in redundancy and self-recovery will sacrifice capacity to some degree, which you'll need to factored-in during the budgeting process.

- RAID 0 – High performance, no redundancy (at least two drives)
- RAID 1 – Good performance, high redundancy (at least two drives)
- RAID 5 – Better performance, better redundancy (at least three drives)
- RAID 10 – High performance, high redundancy (at least four drives)

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Upgrades That'll Keep You Humming Along

For those of you who prefer to do your PC spring cleaning in the fall, you're in luck. This month's page of updates is positively jam-packed with apps to tweak, change, reconfigure, or otherwise modify your system settings. Fontface Ninja and ShareX are both fun and functional.

SOFTWARE UPDATES

Fontface Ninja For Chrome 3.0

Sure, Fontface Ninja is a fairly specialized browser extension, but it's nonetheless deadly effective at what it does. When it's installed, Fontface Ninja snatches font information (including name, size, spacing, color, and so forth) from websites faster than you can knifehand strike a practice dummy. The extension even gives you the option to buy fonts that catch your eye. In version 3.0, our tiny typeface martial artist gets a new UI, improved speed, font detection based on metadata, and more. The latest update also fixes display problems with some websites.

https://fontface.ninja

NetSetMan 4.5.0

Short for Network Settings Manager, this is a solid option for anyone who wants to take a little more control over their network. Halfway to version 5.0 (numerically, at least), version 4.5.0 delivers a Network Scanner tool, which can scan networks according to IP range (both IPv4 and IPv6), subnet, and ARP and NDP cache. The Network Scanner is multithreaded, too, which is very helpful for rifling through an extremely wide range of IPs. It also has a real-time search feature. Aside from this new feature, the update squashes a swarm of bugs and introduces "lots of minor fixes and adjustments."

www.netsetman.com

Patch My PC 3.2.0.0

Billed as a "free, easy-to-use program that keeps over 165 apps up-to-date on your computer," Patch My PC is yet another utility that makes PC maintenance less menial. With the latest version, you'll need Microsoft .NET 4.5 to continue using Patch My PC, so make sure you've updated that, as well. Also note that the program's log has now moved to %temp%\PatchMyPC.log. Version 3.2.0.0 makes some improvements to Patch My PC's application closing and scheduler.

https://patchmypc.net

ShareX 11.9.1

This FOSS screen capture tool boasts "over nine years of active development," and it shows. In addition to having an arsenal of different screen capture methods, ShareX can also upload to a variety of image and text upload sites. The 11.9.1 update in mid-August merely fixes a few bugs, but version 11.9.0, released eight days earlier, delivers a bunch of goodies. There's a new batch image thumbnailer tool, custom domain support for Microsoft Azure storage, a cursor tool for the program's Region Capture ability, and Italian language support. Also, this update officially brings ShareX to the Windows Store.

https://getsharex.com

Tweaking.com
Windows Repair 4.0.3

There's little doubt you already have a gang of utilities that keeps Windows clean; why not add another? Not much changes in the latest version of Windows Repair—a pair of bugfixes remedies problems with the app's Repair WMI function. However, Tweaking.com unleashed version 4.0.0 at the end of July, and it's loaded with new features. In addition to a sparkling new UI, Windows Repair's Systray icon menu gives users the option to restart in Safe Mode, and a Repairs Preset feature lets you customize how you want Windows Repair to clean your OS.

www.tweaking.com

Winaero Tweaker 0.8

Repairing, tweaking, whatever you want to call it—we're suckers for apps that help power users get the most out of their OS. Headlining version 0.8 is a brand-new Import/Export wizard. According to Winaero, Tweaker users (Tweakers?) have been clamoring for this feature for a while. Fairly self-explanatory, the wizard lets you export your tweaks to a file and then import them on another system. It also lets you pick and choose which tweaks you want to import from an export file, in case you have multiple systems that require different tweaks. Other slick new tweaks include setting the Lock Screen slideshow duration and disabling error reporting.

winaero.com

DRIVER BAY

NVIDIA GeForce
Game Ready Driver 385.28

A pair of games receive optimizations in the latest driver for NVIDIA's GeForce graphics cards. Agents of Mayhem has received NVIDIA's Game Ready treatment, while Killing Floor: Incursion now has Game Ready VR optimizations.

https://www.geforce.com

Ransomware Resurgent
High-Profile Attacks Plague Systems Around The World

Like it or not, malware in one form or another has been around almost as long as computers themselves. You'd think that after years of malicious attacks our collective intelligence and experience would have created a natural defense against all but the most sinister threats. After the fourth time telling Grandpa he needs to stop clicking emailed links from the bank where he doesn't even have an account, you expect him to treat the next email from "Wells Fargo" with a little suspicion. You tell him that Microsoft's regular Windows updates aren't just Redmond's attempt to personally annoy him and can only hope he regularly grabs the patches and hotfixes that plug security holes.

Granted, sometimes it's not Grandpa's fault. Otherwise legitimate websites are hijacked all the time, and files you have no reason to suspect as dangerous become attack vectors. Of course, it's possible for the most vigilant users, especially power users, to protect their systems, but everyday folks are arguably just as susceptible to malicious attacks now as they were during the heyday of macro viruses. As long as there's money to be made, hackers gonna hack, and they will of course develop more sophisticated means of doing so.

Over the years, when a particular type of malware is particularly virulent, it enters the public conscious, and everyone, even Grandpa, learns about it. The '80s gave us Elk Cloner and Christmas Tree, while the '90s introduced the world to Michaelangelo and Melissa. Take your pick of notorious malware that has swept across the internet since the turn of the century.

Even with a few months to go, our money's on 2017 going down as the year of ransomware. The most notorious of them all, WannaCry, wreaked havoc on hundreds

Dating back to 1989, ransomware isn't a new, or even recent, invention, among cybervillains, but it's been in the spotlight this year, especially after the WannaCry cryptoworm brought businesses and organizations to their knees in early May 2017.

of thousands of systems in virtually all of the industrialized world. Damage estimates vary, but one cyber risk modeling firm, Cyence (https://www.cyence.net), initially pegged losses at $4 billion. Regardless of the final tally, WannaCry's devastation puts it on the scale of a natural disaster. Some of the companies, government agencies, and other entities hit by WannaCry include the United Kingdom's National Health Service, Fed Ex, Honda, and the University of Montreal. WannaCry isn't alone, though, as ransomware continues to plague both big organizations and individual users.

All Your Data Are Belong To Us

Ransomware has been making its targets cry long before WannaCry infected systems globally. To find the first known instance of ransomware, you have to set your wayback machine to 1989, when Dr. Joseph Popp distributed what is known as the AIDS Trojan. Popp distributed the Trojan on a floppy disk to members of a mailing list that he belonged to. The disks were labeled harmlessly "AIDS Information Introductory Diskette," but when a victim opened the disk, the Trojan replaced the system's AUTOEXE.BAT file. Eventually it would encrypt files and hide directories on the system. Then, it instructed its victim to send $189 to a Panamanian post office box in exchange for a separate program that would properly restore the files. Because of its demand for payment, the AIDS Trojan earned the ignominious honor of

The WannaCry ransomware attack struck around the world, hitting government entities such as England's National Health Service and businesses like FedEx, Honda, Renault, and Russian telecom provider Megafon.

ransomware rampages through storage devices, encrypting data as it goes. Once the data is encrypted, crypto ransomware then "identifies itself" to the victim and instructs them to submit payment, almost always in Bitcoin, to decrypt the files. If you've ever voluntarily encrypted your files, then you know that it's difficult bordering on impossible to break strong encryption. In addition to WannaCry, two notorious examples are CryptoLocker and CryptoWall.

Instead of wrapping files in an impenetrable layer of encryption, locker ransomware attacks users in a different way. Whereas crypto ransomware makes data inaccessible but generally leaves the rest of the system usable, locker ransomware locks down access to the system as a whole, requiring a ransom before it can be used again. Locker ransomware typically doesn't target files themselves, and users often can defeat the malware using security software.

When locker ransomware does succeed, it does so with social engineering. The lock screen that notifies the victim of the attack

being the first publicly distributed piece of ransomware.

Broadly speaking, there are two types of ransomware. Crypto ransomware, or encrypting ransomware, preys on the assumption that a victim's system contains troves of irreplaceable data, such as family photos, work projects, and important personal/financial documents, which people value enough to be willing to pay a ransom to recover. Once it infects a system, this type of

WannaCry: A Timeline Of Events

Although WannaCry was snuffed out almost as quickly as it spread, it nonetheless caused tremendous damage to computers in every continent. (Technically, Antarctica was spared.) The attack occurred May 12, 2017, but it had been brewing well before that.

March 14, 2017. Microsoft issues Microsoft Security Bulletin MS17-010. The security update fixes a vulnerability that lets an attacker execute code remotely by sending "specially crafted messages" to a Microsoft SMB server. Natrually, systems without the update remain vulnerable.

April 14, 2017. A hacker collective known as the Shadow Brokers releases EternalBlue, a network exploit, and DoublePulsar, a backdoor. Both of these tools are widely believed to have been developed by the U.S. National Security Agency. A combination of EternalBlue and DoublePulsar will become the means by which WannaCry spreads.

April 21, 2017. Swiss security firm BinaryEdge estimates that over 100,000 systems have been infected with DoublePulsar. By April 27, the number jumps to over 425,000.

May 12, 2017. WannaCry strikes Europe early in the morning. Spanish mobile telecom provider Telefónica is among the first of many large entities to report that some of its systems have been compromised in the attack. Later the same morning several UK hospitals are crippled when WannaCry infects the country's National Health Service. Other victims include French automaker Renault, Germany's Deutsche Bahn, Russian telecom MegaFon, and FedEx. WannaCry demands payment in Bitcoin, a common practice among ransomware.

May 12, 2017. In the early afternoon, web security professional Marcus Hutchins discovers a kill switch within WannaCry that greatly impedes its propagation. (Coincidentally, on August 2, 2017, the FBI arrested Hutchins in Las Vegas for allegedly creating the Kronos banking malware.)

May 12, 2017. Microsoft issues a patch for Windows XP and Windows Server 2003, a move that Phillip Misner, Principal Security Group Manager, Microsoft Security Response Center, calls "highly unusual," considering Microsoft has ceased official support for these OSes. Weeks later, security firm Kryptos Logic reports that WinXP systems are not nearly as vulnerable to WannaCry as initially believed.

May 15, 2017. Thanks to Hutchins' kill switch discovery and affected groups updating their systems, WannaCry is eventually stopped. However, experts warn that updated versions of the ransomware could reappear.

typically tricks them into believing they've run afoul of the FBI, IRS, or some other equally intimidating government agency. The lock screen then accuses the user of illegal online activity or other crimes and instructs them to pay a "fine" to lift the lock. Locker ransomware aims to present serious enough threats to its victims that they won't seek help, either from friends or legitimate law enforcement, out of fear they've committed a crime.

Although ransomware has generated millions in ransom payments over the years, its true damage comes from the attacks themselves. It's difficult to put a price on family photos, but when ransomware strikes a business, metrics such as company downtime, hiring a security firm, and monetary damages in the form of fines and lawsuits are costly. For example, Cybersecurity Ventures estimated that global ransomware losses in 2017 will exceed $5 billion. Another attack on the scale of WannaCry could push that figure even higher.

Petya: A Coyote In Wolf's Clothing

Just as organizations began to emerge from the wake of WannaCry, it appeared that another ransomware attack was ready to besiege systems worldwide. This new outbreak initially had all the markings of textbook ransomware. The cyberattackers used a modified version of existing ransomware called Petya and, like WannaCry, relied on the EternalBlue exploit to propagate it. On June 27, this new strain of ransomware began its attack. In the aftermath, security experts traced the origin to an update to Ukranian tax software MeDoc.

This version of Petya looked like ransomware, and initially acted like it, but further inspection of its behavior ultimately revealed a different, and arguably more nefarious, purpose behind the attack. Rather than encrypt a system's files and genuinely demand a ransom payment, the new Petya variant often wiped drives completely, rendering data irretrievable even if there was an attempt to break the encryption and/or pay a ransom. Older versions of Petya targets

Hackers Hold Hollywood Hostage

Some hackers just want to watch the world burn, but others are motivated by cold, hard cash. The movie and television industries generate billions of dollars every year, which naturally makes them attractive marks for digital bandits. Over the last few years, several major studios have found themselves in hackers' crosshairs. The attacks aren't ransomware in the same sense as WannaCry, but rather examples of leakware, where hackers threaten to expose/leak content they've stolen unless the victim pays a ransom.

Sony Pictures. On November 24, 2014, a group calling itself "Guardians of Peace" declared that it had compromised Sony Pictures' computer systems. Shortly thereafter, the hacked data explodes across the internet; Sony employees' personal information, embarrassing internal email exchanges, film scripts, and unreleased films all leak. Ultimately, U.S. intelligence agencies determine that North Korea is behind the attack, either directly or as the sponsor. Most believe that Sony's release of the comedy "The Interview," which involves a plot to assassinate North Korean dictator Kim Jong Un, was the primary motivation for the attack.

Netflix. A hacker or hackers operating under the moniker "TheDarkOverlord" breaches Larson Studios, a post-production company located in Hollywood. Larson's owners are contacted by text message December 23, 2016, and then via email on Christmas. The owners wire $50,000 in Bitcoin to the hacker(s) to prevent the leak of most current season of "Orange is the New Black." TheDarkOverlord makes similar demands to Netflix itself in April 2017, and when Netflix refuses, the hacker(s) release the full season online, several weeks ahead of its official premiere.

Disney. Coming right on heels of the WannaCry attack (though unrelated) Disney CEO Bob Iger reveals during a May 15 company town hall that hackers have contacted Disney with claims they've stolen a film that has yet to be released. Although unconfirmed, people overwhelmingly suspect the movie is the fifth installment of Disney's "Pirates of the Caribbean" franchise. Eventually, Iger says that Disney determined the threat was a hoax. "Pirates of the Caribbean: Dead Men Tell No Tales" premieres May 26 without leaking online.

HBO. Thanks to massive success of "Game of Thrones," as well as other shows, HBO has been no stranger to piracy and leaked content, though on July 31, 2017, HBO confirmed that it was the victim of a cyberattack. A hacker or hackers calling himself "Mr. Smith" initially claims to have stolen 1.5TB of data and dumps unreleased episodes of "Ballers" and "Room 104," as well as a script for an upcoming episode of "Game of Thrones." Mr. Smith demands a $6.5 million ransom and also leaks an email exchange with an HBO exec offering to pay $250,000 as a "bug bounty," suggesting the studio might be willing to comply with the demand. HBO declines to pay the ransom as content continues to trickle out.

Game of Thrones / Courtesy of HBO

Petya, another recent strain of ransomware, initially appeared to be another epidemic of ransomware to hit systems worldwide. However, after further analysis of the variant of Petya that was unleashed in June, security experts believe the attack was not a traditional ransomware attack. Rather, the attackers used their Petya variant as a smokescreen to draw attention away from a massive cyberattack against Ukraine, taking advantage of WannaCry's widespread media coverage and deploying their malware, later dubbed "NotPetya" or "Nyetya," to masquerade as more ransomware.

and encrypts the Master File Table, while the malware used in the June 27 attack encrypted files en masse. Eventually, the ransomware earned the name "NotPetya" or, more cutely, "Nyetya." However, even though NotPetya didn't target wallets like ransomware, the reason behind the attack was no laughing matter.

Security professionals now believe that the release of NotPetya was a misdirection, meant to divert news outlets and the general public away from a large-scale cyberattack against Ukraine itself. Although several other countries reported NotPetya attacks, Ukraine suffered the majority of the damage. The attack knocked out the Chernobyl nuclear plant's automated radiation monitoring system and also affected several government departments, transportation and communication (including Boryspil International Airport, Ukranian Railways, and Ukrtelecom), and banks. Infected computers appeared to request ransom payments to restore full access, but instead NotPetya simply wiped out important files. In the aftermath, Ukraine's official state

security department declared that Russia was behind the attack as part of ongoing hostilities between the two nations (a charge that the Kremlin obviously denied).

Future Petya or NotPetya attacks are a possibility, as well. Unlike WannaCry, the malware doesn't contain a kill switch that could be activated to stop its spread.

Ransomware In The News

Although WannaCry and NotPetya dominated news cycles, ransomware continues to be a threat that security firms and government agencies treat with constant vigilance. On August 28, the IRS identified and issued a warning about a new phishing attack that attempts to trick people into installing ransomware.

"This is a new twist on an old scheme," IRS Commissioner John Koskinen said in an official press release. "People should stay vigilant against email scams that try to impersonate the IRS and other agencies that try to lure you into clicking a link or opening an attachment."

Adding injury to injury, NHS Lanarkshire, which operates hospitals in

Scotland's North and South Lanarkshire regions, recently admitted that it suffered another ransomware attack after already falling victim to WannaCry. NHS Lanarkshire said that it uncovered the ransomware, an updated strain of Bitpaymer, on August 25, and its IT team worked over the weekend to reverse the damage. Although the hospital group indicated the new attack wasn't as severe as May's WannaCry breach, it underscores how prime ransomware targets such as hospitals are under an ever-present threat of future assaults.

Despite the general advice that groups and individuals should not capitulate to hackers' ransom demands (because doing so further encourages these criminals to launch additional ransomware attacks, and because they often don't honor their promise to restore user data even after a ransom has been paid), people regularly pay up. In an August 30, 2017 letter, Dorchester School District Two superintendent Joseph Pye revealed that 25 of the district's 65 technology servers were hit with unspecified ransomware. After hiring two cybersecurity companies and huddling with the state's Department of Education Chief Security Officer, South Carolina Law Enforcement Division, and "other law enforcement agencies," Dorchester agreed to pay a $2,900 ransom to decrypt the compromised files. The school district was able to recover the data on 24 servers, while the final server was "corrupted, rendering it inaccessible by us or anyone else."

As we went to press, cybersecurity provider AppRiver announced in its blog that it detected an explosion of over 23 million spam emails containing the Locky ransomware. Particularly striking is this variant of Locky's ransom demand of 0.5 Bitcoin, which equaled over $2,350 at the time of this writing. Historically, ransomware has asked for a much smaller payment, usually $300 to $600, a possible hint that hackers want to make ransomware more costly.

Either way, the recent and continuing spate of ransomware makes it a good idea to give Grandpa a call and remind him of the danger. ∎

CPU
Game Of The Month

Yeah, we know you have blogs to post, video to encode, reports to write, and code to compile. We do, too, but you have to take a break once in a while (and maybe blow some stuff up). That's why each month we give you the lowdown on what to expect from the latest interesting games.

Profound

BY CHRIS TRUMBLE

$29.99 (PC, PS4) • ESRB: (M)ature • Ninja Theory
www.hellblade.com

On the surface, Hellblade: Senua's Sacrifice is an action game where you play the role of a grieving Celtic warrior on a quest to free her lover Dillion's soul from hell after he was brutally murdered by Viking raiders. In truth, though, it's a great deal more than that. For one thing, it's irrefutable proof that Ebert was wrong: Games can, in fact, be art. I've been playing videogames for the better part of 40 years, and I've never been surer of that than while playing this one.

Hellblade looks and sounds amazing in the technical sense, but more importantly, every image and sound in the game has been painstakingly created to immerse you in Senua's world and let you see it through her eyes. That's true in some sense for many games, but in the case of Hellblade, the developers at Ninja Theory took immersion a step further.

Not many games feature protagonists with psychosis, but Senua suffers from mild to severe hallucinations and hears voices throughout the game; her illness has a profound impact on the gameplay experience and the story. Perception can be a tricky thing for all of us, but for Senua (and, by extension, for you), it is sometimes very difficult to know what around her is real. Ninja Theory spent two years working with Dr. Paul Fletcher, a professor of Health Neuroscience and psychiatrist at the University of Cambridge, and also spent time working with people who experience these things in their daily lives in an effort to provide experiences that ring true.

The result is that Senua's journey to hell is a physical representation of her inner journey through another kind of hell, and her fights against hulking

Northmen and their gods are mirrored by her struggles with voices telling her that she is worthless, she is to blame for Dillion's death, and so on. The interesting thing, though, is that some of the voices Senua hears encourage her. Some seek to guide her and can offer helpful advice, while others taunt and try to deceive. The trick, then, is to discern which voices to heed and which ones to ignore. Her visual struggles create another interesting gameplay mechanic; at times you will catch fleeting glimpses of a path you need to follow to solve a puzzle, only to have it disappear. In some cases, there are specific actions you can take to rediscover such things, other times they seem to appear and disappear more randomly.

Combat in the game takes place infrequently compared to most action games, but it is very well done and can be quite visceral. Early in the game, Senua becomes infected by the Darkness that plagues her journey, and the game warns that each time she falls in combat, that infection will spread. If she becomes fully infected, the game tells you, "All progress will be lost." Although I'm generally not a big fan of permadeath systems in games, Hellblade's implementation is, like the rest of this game, very well done.

We usually primarily judge games on whether or not they are "fun," but that seems too trivial a way to evaluate Hellblade: Senua's Sacrifice. I don't know that I would call it fun overall, although the combat can be fun, and some of the puzzles are quite fun to solve. One thing's for sure; this game is a profound experience that plumbs the depths of human emotion. If you're ready for that, there's currently no better way you can spend $30.

They Don't Crash 'Em Like They Used To

BY ANDREW LEIBMAN

$11.99 (PC) • ESRB: n/a • Moonbyte
www.crashday.2tainment.com

On principle, I have no qualms with retro remakes and rereleases of classic games. Whether a game qualifies as a "classic," and is therefore worthy of a revival, is also entirely subjective. I've been gaming on PCs since the since the early '90s, and as such, there are only a handful of games from 2006 that would budge the needle on my nostalgia meter, including The Elder Scrolls IV: Oblivion, Dead Rising, Gears Of War, and Tom Clancy's Ghost Recon: Advanced Warfighter. The original Crashday never even showed up on my radar, at least not to the same extent that Burnout Revenge, FlatOut 2, and Auto Assault did. Incidentally, all three of those genre gems were rated better than Crashday.

But we're not here to talk about yesterday. Crashday Redline Edition is a faithful remastering that takes the arcade racer to new places. The game's developer, Moonbyte, the same one that created the original, crammed seven game modes into this remake, including Wrecking Match, Stunt Show, Race, Hold The Flag, Pass The Bomb, and Bomb Run. The game modes generally boil down to straight non-combat races, or destruction derby-style arena-events or races where your car is equipped with missiles and a machinegun. There are a handful of mini games, though most modes are pretty dry when playing alone, getting considerably more exciting when you swap AI cars with up to eight of your friends in the online modes. With its release on Steam, matchmaking streamlines this process considerably.

The Career Game mode is typically the highlight of an arcade racer, letting you methodically unlock tracks, earn cash for better cars, and upgrade your favorite rides. In Crashday Redline Edition, this mode is dragged down by some pretty awful voice acting, and a script that was probably cringe-worthy even a decade ago.

Other features worth mentioning are a built-in track editor, a new lighting engine and improved textures, enhanced controls, better gamepad support (we played with an Xbox One controller), a total of 36 tracks (10 of them are new), 12 vehicles (these are unlicensed knockoffs), and a variety of tarmac, dirt, and urban racing environments.

The game also supports avatars, voice chat, and mods, via the Steam Workshop. We loaded up a few spiffy new car models, a couple of custom tracks, and even an alternate soundtrack, enabled them from the game launcher, and got to take each for a spin once in the game. Although we were rather lukewarm on Crashday Redline Edition, the Steam Workshop integration has the potential to breathe new life into this game for years to come. The only real question here is whether there's a large enough and talented enough audience to churn out quality mods for the foreseeable future.

Despite all of the improvements, however, at the end of a several-hour session I came away feeling like I had just played a decade-old game. The controls are unrealistic even for arcade-style racer standards, and the difficulty curve is pretty steep, which is sure to turn off the casual race fans that tend to gravitate toward arcade-style racers like this. Visually, the game looks its age, but framerates were solid and we didn't encounter any glitches or annoying bugs.

For fans of the original, Crashday Redline Edition is a decidedly retro – and blessedly inexpensive – way to scratch the combat racer itch with their friends. For most everyone else, it just feels outdated. ∎
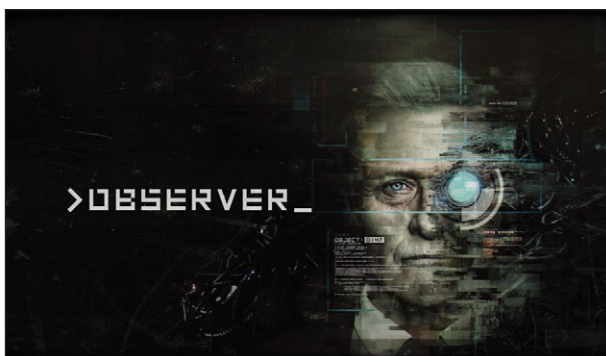
CSI: OMG

BY VINCE COGLEY

Price $29.99 (PC, XOne, PS4) • ESRB: (M)ature • Aspyr
observer-game.com

Last year, I reviewed Layers of Fear, a psychedelic horror game from Polish developer Bloober Team. LoF puts you inside the mind of a master painter who had slowly lost his grip on his sanity. Set inside the requisite Victorian manor, LoF mostly followed the horror game playbook, but its seamless room reconfiguration mechanic and a trio of genuinely solid endings left us encouraged for future Bloober projects.

Bloober is back with Observer (stylized as ">observer_"), which couldn't be any more different from Layers of Fear, at least as far as setting is concerned. The stately mid-19th century mansion is long gone, as Observer rockets you to the future (2084, to be precise), where life is . . . not that great. In this cyber-punk hellscape, humanity can't seem to catch a break. First, a deadly infection known as the Nanophage (basically, the nifty nanobots we've implanted in ourselves go haywire and start attacking their hosts) strikes, then the Great Decimation (think World War III and IV put together) takes care of most of the major world powers and a nice chunk of the global population. That's the bad news.

The good news is that the game's protagonist, Dan Lazarski (wait, that's Rutger Hauer of "Blade Runner" fame!) has managed to make a name for himself as a skilled Observer, essentially the thought police—literally—of Chiron, Inc., the megacorporation that doubles as the game's government. By using devices called Dream Eaters, Observers hack into their subjects' brains, extracting vital information but also all the personal demons each subject is battling.

As the game begins, Lazarski is working his beat when he receives a cryptic call from his estranged son, Adam, who sounds like his life choices may have caught up with him. Dan tracks the call to a Krakow slum. In short order he discovers a gruesome crime scene, and his investigation begins. Right away, you get to use Dan's cybernetic enhancements to help pick apart the crime scene.

It's clear that Bloober has come a long way since Layers of Fear, as Observer is a major leap forward in almost every regard. The neat little room reconfiguration trick they used in LoF is back, and it's better than ever. When you break into someone's mind, the game gives you visions of these broken souls' lives in a mesmerizing, compelling, and terrifying way. As far as sci-fi goes, the technology isn't really anything new, but the game's execution of navigating a person's psyche is as good as or better than anything I've seen in film or television.

I also enjoyed Observer's side quests, which might be even better than the main narrative (also solid). Sure, you can choose not to follow these rabbit trails, but why would you? Bloober has built an astonishingly rich dystopian world, and experiencing it is more than half the fun. Using elements of police procedural/cyberpunk horror as its delivery mechanism, Observer earnestly explores topics like poverty, totalitarianism, and cybernetics with a touch that most games like this sorely lack. By the time I finished the game, I felt that I was only scratching the surface of a fully realized and compelling universe. My biggest regret about Observer is that there wasn't more of it.

The 3D character modeling could use some work, and I thought some of the cues that guide you through Observer's "levels" (each person's mind) were a bit too vague, but everything else, including the voice acting, dialogue, sound design, writing, etc. are outstanding. I can't wait to jack into the next nightmare Bloober Team creates. ■

Augmented Reality
To The Rescue

BY ANDREW LEIBMAN

$19.99 (PC)   •   ESRB: (M)ature   •   The Fullbright Company
www.tacoma.game

In The Fullbright Company's breakout debut, Gone Home, you explore an empty house reading notes and listening to audio cassettes to discover why your parents and sister are gone and nothing in the sprawling estate is as it seems. Even if I didn't know that TACOMA was Fullbright's sophomore outing, I might have guessed it after playing for 20 minutes.

Although the storytelling devices and narrative tempo are similar between both games, the settings couldn't be more at odds. The first game takes place in the '80s in a large house in Portland Oregon, and TACOMA takes place in the year 2088 on the Lunar Transfer Station Tacoma, orbiting 200,000 miles above the Earth. Artificial Intelligence is a highly regulated but vital part of life in space, and massive corporations, including Amazon, Carnival, and the Tacoma's own Venturis Corporation effectively keep people in a kind of indentured servitude to pay for the mandatory education and training required to remain a productive member of society. In TACOMA's universe, when Capitalism wins, we all lose.

The game opens with the player character, Amy Ferrier, as she docks her shuttle to the abandoned Tacoma. Your job, as a loyal employee of the Venturis Corporation, is to figure out what happened to the missing crew, retrieve the station's AI ODIN (Operational Data Interface Network), wipe all evidence, and report back to your bosses.

On the state-of-the-art Tacoma, your clues aren't just scattered across dozens of sticky notes, journal entries, and cassette tapes; you've got AR. As you move from pod to pod, you can detect and unencrypt a series of key conversations and events, and replay, pause, and rewind them as you see fit. These augmented reality sequences are what really sets Tacoma apart from Gone Home. You can actually see the physical shapes and hear the voices of the various crew members as they interact with one another, communicate remotely with friends and family, and watch them in their intimate private moments.

Everything starts off so quietly. You're waltzing around in your mag boots, getting to know the crew by reading their emails, sifting through their belongings, breaking into lockers, and breathing down their virtual necks to see the pass codes they're using to open otherwise inaccessible portions of Tacoma. Just as you're beginning to feel as if you're one of the team, the creepy one with complete access to their innermost secrets, disaster strikes. Communications are cut off and the station's oxygen supply is almost completely vented into space.

For Amy Ferrier, there's no immediate danger, but as the AR recordings playback in chronological order, showing things going from bad to worse, you can't help but begin to feel for them, to experience their anxieties and develop a real sense of urgency to uncover the truth.

Although it only took me about four hours to complete, I found Tacoma's narrative engaging, the characters interesting, and the dystopian future setting compelling. The Tacoma station has a fairly generic space aesthetic, but the game looks good and ran well on a system with modest hardware.

My one big gripe with the game is that it didn't really surprise me. There's no real reversal, or Aha moment that reverberates well beyond the moment when the credits roll. Those who like this type of narrative-driven game won't be disappointed for the modest asking price, but I can't shake the feeling that Tacoma needed, and deserved, a stronger ending. ∎

Technically Speaking

Q&A With GIGABYTE's Brian Ngo

GIGABYTE recently unveiled its brand-new AORUS GTX 1070 Gaming Box, a compact external appliance that contains a GeForce GTX 1070 graphics card and a 450-watt power supply. You can connect the Gaming Box to a laptop and instantly turn it into a 4K, VR gaming-ready powerhouse. We talked to GIGABYTE Technical Marketing Specialist Brian Ngo to find out more.
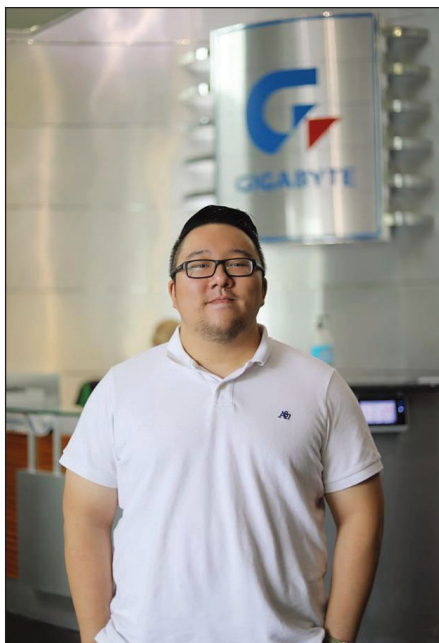
Q: What were GIGABYTE's goals in designing the AORUS GTX 1070 Gaming Box?

BN: Staying true to our gaming ethos, we wanted to provide a compelling option in the eGPU market and offer a true plug-and-play device and experience that can transform any Thunderbolt 3 laptop into a gaming powerhouse.

Q: Which AORUS GTX 1070 does the Gaming Box contain?

BN: Although the GTX 1070 included in the Gaming Box is not of the AORUS family, it is an overclocked Mini-ITX model.

Q: How do you get enough bandwidth from an external device to equal a PCIe 3.0 x16 slot?

BN: To get enough bandwidth from an external device to be close to a PCIe 3.0 x16 slot, we had to use a protocol that offered the highest bandwidth available, so we turned to that fastest available port, Thunderbolt 3. Thunderbolt 3 offers a bandwidth of up to 40Gbps, up to eight times faster than USB 3.0 and four times more video bandwidth than HDMI.

Q: What other advantages are there to using Thunderbolt 3.0 to connect the Gaming Box to a laptop?

BN: As Thunderbolt 3.0 becomes adopted more widely, we'd hope that the gaming box would be universally compatible with a growing portfolio of Thunderbolt 3-certified devices.

Q: What are the system requirements for using the Gaming Box?

BN: You just need any Thunderbolt 3-certified and -compatible device, such as a laptop or Ultrabook.

Q: What other connectivity options does the Gaming Box offer?

BN: Gaming Box is equipped with three USB 3.0 ports for adding additional devices, such as a keyboard, mouse, and webcam, and a variety of other USB-hosted devices. In addition to the three USB 3.0 ports, we have included another Quick Charge 3.0 port, allowing you to charge your phone or other mobile devices up to four times faster than conventional chargers.

Q: What else can the Gaming Box do besides provide cutting-edge graphics capability to a laptop or Ultrabook?

BN: It can also be used to accelerate rendering times for professional-use applications such as Adobe Photoshop, Blender, and many more, adding even more functionality and expandability to your compatible laptop or Ultrabook.

Q: From what we've seen, the AORUS Gaming Box also offers some RGB lighting options, correct?

BN: Yes, we offer RGB Fusion, our fully customizable RGB lighting option that users can control and turn off through our Overclocking and RGB software, the AORUS Graphics Engine.

Q: OK, so what if someone who uses the Gaming Box wants to take his laptop and Gaming Box to a LAN party?

BN: Great, that's exactly what we'd hope for, so we have also included an AORUS carrying case (also known in our office as "the lunchbox") alongside the AORUS GTX 1070 Gaming box.

Q: How does the design of the Gaming Box meet the thermal needs of the GeForce GTX 1070 inside?

BN: We used an open-air design on the side panels to allow proper ventilation along with an array of 40mm fans to direct airflow.

Q: You know *CPU* readers are going to want to know this next one: Can users overclock the GTX 1070, and if so, how would they go about doing that?

BN: Yes, of course you can overclock the GTX 1070, and you would be able to do so through the AORUS Graphics Engine.

Q: Do users need anything to use the Gaming Box that isn't included in the package?

BN: Everything you need to get the Gaming Box up and running will be included in the package other than the Thunderbolt 3-compatible device.

Q: What is the AORUS GeForce GTX 1070 Gaming Box's MSRP, and when will it be available at retail?

BN: Our AORUS GeForce GTX 1070 Gaming Box's MSRP will be $599. It is currently available at Newegg.com and Amazon.com in the United States and will be available August 12th in Canada.

Q: Does GIGABYTE have any plans to offer a Gaming Box with a GTX 1080 or even a GTX 1080 Ti inside?

BN: At the moment, we do not have plans for one in the pipeline, but this may change as demand rises. ∎

Look For *CPU* At These LAN Parties

09.01-04.17
PAX West
Seattle, WA
west.paxsite.com

09.02-03.17
NAG LAN Party
Hutchinson, KS
www.nagitechs.net/nag-lan-party

09.09.17
Glowhouse Gaming Launch Party
Santa Clarita, CA
www.glowhousegaming.com

09.15.17
Oklahoma Gamers Group
Oklahoma City, OK
www.okgg.org

09.15.17
Source Gaming Lounge
Denton, TX
sourcegaming.org

09.16-17.17
LanOC v21.0
Van Wert, OH
lanoc.org/lan-parties

09.22-24.17
PONG EXPO LAN
Menomonie, WI
pong.uwstout.edu

09.29.17
Bluebonnet LAN
Arlington, TX
utaesports.com

09.29-10.1.17
BoiseLAN 5.0
Boise, ID
https://www.boiselan.net/forum/lan/

10.07.17
KCGames On 77
Kansas City, MO
kcgameon.com

10.07-08.17
River Valley LAN
Russellville, AR
www.outofeleven.com/rivervalleylan

10.21.17
Oklahoma Gamers Group
Oklahoma City, OK
www.OKGG.org

10.21.17
Source Gaming Lounge
Denton, TX
sourcegaming.org

10.21-22.17
Laclede's LAN 17
St. Louis, MO
www.lacledeslan.com

CPU

Across The Nation—& Beyond!

10.27-29.17
FortCON 2017
Fort Wayne, IN
www.fortlan.org

10.27-29.17
BaseLAN 32
Winnipeg, MB
www.aybonline.com/baselan-32

11.03-06.17
PDXLAN 2017
Portland, OR
www.lanreg.org/pdxlan/pdxnov2017

11.17-19.17
Windy City LAN 3.0
Chicago, IL
www.windycitylan.com

11.10-11.17
True Gamerz Expo
Jacksonville, FL
www.beaucoreenterprises.com

11.17-19.17
November LAN
Menomonie, WI
pong.uwstout.edu

11.17-19.17
San Diego Winer LAN-A-THON
San Diego, CA
www.SanDiegoLAN.net/LANaThon.html

11.18.17
Oklahoma Gamers Group
Oklahoma City, OK
www.OKGG.org

11.18.17
Source Gaming Lounge
Denton, TX
sourcegaming.org

11.25-26.17
Wichita LAN 34
Lyons, KS
www.facebook.com/events/327652644327719/

12.01-03.17
KCGames On 78
Kansas City, MO
kcgameon.com

12.16.17
Dirty Santa Comes To The LAN
Oklahoma City, OK
www.OKGG.org

12.16.17
Source Gaming Lounge
Denton, TX
sourcegaming.org

Would you like us to help promote your next LAN?

Give us a call at **1.800.733.3809**

We'll be glad to consider your event

Q&A With Brian Farrell

PrimoChill Founder Talks EximoSX Radiators

Q: Your new EximoSX radiators are "designed for great performance in a variety of system conditions." Can you talk about what that means and how they are engineered to do that?

BF: "System conditions" is how we tackled the design. The concept was executed by determining where the placement, functionality, and ventilation was in most modern cases, and how we could make sure our radiator would fit and perform.

Q: We certainly appreciate a thin radiator; some cases don't leave much room for radiators of traditional thicknesses. But is there a tradeoff in performance for that compactness?

BF: The tradeoff is very minimal, if any, as we have found having one or more radiators in a system is not uncommon as well as more efficient. Running multiple thinner radiators supports the most demanding of systems.

Q: Why did you design the EximoSX with seven dual-pass coolant lanes?

BF: We packed in seven dual-pass lanes to give the highest possible flow rates for the cooling loop, which in turn increases efficiency.

Q: Your site mentions that EximoSX radiators have a high-density tube-to-fin ratio to aid in heat dissipation; how does the EximoSX's tube-to-fin ratio compare to that of the average radiator, and how does that affect heat dissipation?

BF: Well, there are not a lot of average radiators anymore; most radiators are fine tuned to a specific fan type, whether they

are a high- or low-CFM fan or high pressure. We did our best to make a high enough ratio of fins but low enough to give the user a radiator that they can use with their favorite fan. We didn't want to dictate which fans can and cannot be used. The Eximo works great with any fan of your choosing.

Q: Which of the 18 available color options EximoSX radiators come in have been the most popular so far?

BF: TX Matte Black, Silver, Satin Black True Blue, and Candy Purple.

Q: We've talked a lot lately about radiator construction and the use of copper vs. aluminum. Where does PrimoChill fall on the subject, and why?

BF: PrimoChill stands by Copper 100%. Aluminum radiators pop up time to time as more manufacturers are looking for cheaper alternatives to copper. And each time they fade away because users reject them, as they are not compatible with 98% of the water cooling parts in the industry. Having aluminum parts in this mix just causes more headaches for companies as most users are not aware that the component or fluid they just bought will cause issues down the line because they have an aluminum radiator. Aluminum is not necessary. Later this year we will have an ALL copper cooling kit that will be in the same price range as the aluminum kits without the headache of mixing metals and the problems it creates.

Q: Do you have plans to bundle fans with EximoSX radiators, and if so, which ones?

BF: We do have plans to bundle the radiators. We plan to have three to four new kits coming out at the end of the year, and in true PrimoChill style, they will come with all the parts matching in SX colors.

Q: What else would you like *CPU* readers to know about PrimoChill's EximoSX radiators?

BF: The EximoSX radiators are the next piece of the puzzle to meet the highly desired complete PrimoChill-branded watercooling loop. ∎